ESTIMATION OF THE ORIGINAL SHEAR STRENGTH OF DEEP SEA SEDIMENTS FROM ENGINEERING INDEX PROPERTIES

by

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United States
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THESIS

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Lieutenant Commander, United States Navy
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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN OCEANOGRAPHY

from the

NAVAL POSTGRADUATE SCHOOL
September 1970

ABSTRACT

Multiple linear regression techniques were employed in a statistical analysis of data from 114 deep sea cores in order to derive an equation for predicting shear strength from sediment engineering index properties. Water content, depth of burial, liquid limit, and plastic limit proved to be the only factors significantly influencing the strength in these cores. The multiple and individual correlation coefficients between these four parameters and the logarithm of shear strength proved to be higher than the coefficients computed in a linear strength relation. Additionally, other regression analysis were conducted to determine a water content prediction equation and to investigate correlations among other sediment properties. Water content is shown to be highly correlated with liquid limit. Ancillary to the above analysis, tests were conducted to determine the degree of reproducibility of original liquid limit values from dried sediment material.

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ACKNOWLEDGEMENTS

Appreciation is expressed for the suggestions of Professor R. J. Smith under whose direction this investigation was conducted. Miss Georgia Lyke of the Naval Postgraduate School Library provided able assistance in locating reference materials, and Mr. G. P. Learmonth of the W. R. Church Computer Facility advised concerning computer techniques on numerous occasions. Personnel of the Site Development and Foundation Engineering Divisions of the Naval Civil Engineering Laboratory, and particularly Mr. M. C. Hironaka and Mr. D. G. Anderson provided useful data and helpful comments. The Naval Facilities Engineering Command interest in, and support of the marine sediments research at the Naval Postgraduate School deserves special recognition.

I. INTRODUCTION

A. OBJECTIVE

The primary objectives of this investigation were twofold. First, to develop an equation for the prediction of the original shear strength of deep sea sediments from water depths greater than 6000 feet utilizing their engineering index properties as determined from partially dry sediment cores. From such an equation it is possible to make an estimate of the approximate load-bearing capability of the sediment in a particular oceanic area without conducting a sampling and testing program (Hironaka and Smith, 1969). The second objective was to examine the several possible methods of evaluating the liquid limit of marine sediments to determine the reproducibility of the original value.

B. DISCUSSION

1. General

For many years various institutions and agencies have been collecting deep sea sediment samples for a variety of scientific investigations. Very few of these cores, however, have been analyzed from an engineering standpoint to determine their mass physical properties. Though such samples have proven useful for their intended purpose, a considerable amount of engineering type data has essentially been lost. Many of these cores have been stored for subsequent examination and are available for the determination of those index properties which are presumably not affected by the material being in a dry or remolded condition. It has therefore been hoped that various relations could be developed between the reproducible index properties and the original engineering properties of the sediment.

Index properties are generally defined as those parameters which classify the sediments qualitatively into groups having similar soil engineering properties. Engineering properties, on the other hand, can only be determined on undisturbed samples, and define specific characteristics of the soil which are directly related to its bearing capacity.

Shear strength is currently the most important engineering property of marine sediments from the standpoint of foundation design and bearing capacity calculations. Tschebotarioff (1951) derives the following equation for computing bearing capacity from shear strength:

$$BC = 5.52c\ (1 + 0.38h/b + 0.44b/L) \qquad (1)$$

BC = Bearing capacity (load per unit area)

c = Cohesion per unit area

h = Depth of burial of foundation

b = Width of foundation

L = Length of foundation

For saturated cohesive soils such as marine sediments, it is generally assumed that the angle of internal friction is zero, therefore shear strength equals cohesion (Richards,1961). The above equation has been used in at least one deep-sea foundation study (Hironaka and Smith, 1969).

At present the easiest and most practical method of measuring shear strength is by use of the vane shear device. This is a standard piece of soil mechanics laboratory equipment, and modifications for its use at sea have been developed at the Naval Postgraduate School (Heck, 1970). In working with dried sediment samples, however, it is impossible to directly measure the original shear strength of the material as it existed in its naturally saturated state. It is therefore necessary to establish some

type of relationship, perhaps statistical, between shear strength and certain reproducible sediment properties. Such a value could then be used at least as a preliminary estimate of shear strength for use in equation (1).

Application of an equation relating shear strength with index properties would be particularly valuable in the computation of sediment bearing capacity for several types of situations, provided a stored core is available from the general area of interest.

An example is, loss of an object (such as a submersible) in mid-ocean under conditions where it is immediately necessary for search purposes to know the bearing capacity of the sediment. Application of a shear strength prediction equation, along with data obtained from an available desiccated core could provide a rough estimate in a matter of hours, whereas it might be several weeks before a research vessel could arrive on the scene to core and then test the sediment.

A considerable amount of money could also be saved by alleviating the necessity for a detailed coring and foundation study program in the emplacement of some unmanned experiments on the deep sea floor.

The one basic assumption made before the onset of this investigation was that all index properties are reproducible, even after the sediment has once been dried. Considerable doubt does exist, however, regarding this assumption. In conjunction with the statistical analyses, experiments were conducted to determine the degree to which one of these index properties was reproducible.

2. Parameters

Prior to commencing a statistical study of the available existing data, a survey of the technical literature was made to determine which of

the sediment properties have been found by other researchers to influence shear strength. In order to check for possible correlations and interrelationships among the various parameters, several index properties not identified in this survey were also included in the overall analysis. The properties investigated are described below.

a. Depth in the Core

Some investigations have indicated a general correlation between shear strength and depth below the sea floor-water interface for normally consolidated sediments (Arrhenius, 1952; Richards, 1961; Bjerrum, 1954). Figure 1 from Moore (1961) shows the strength versus depth relationships for sediments from various depositional environments. The overall trend, though variable due to non-homogeneity of the sediment column, results from increasing overburden pressure as sedimentation continues. McClelland (1956) presents an excellent basic discussion of this general subject.

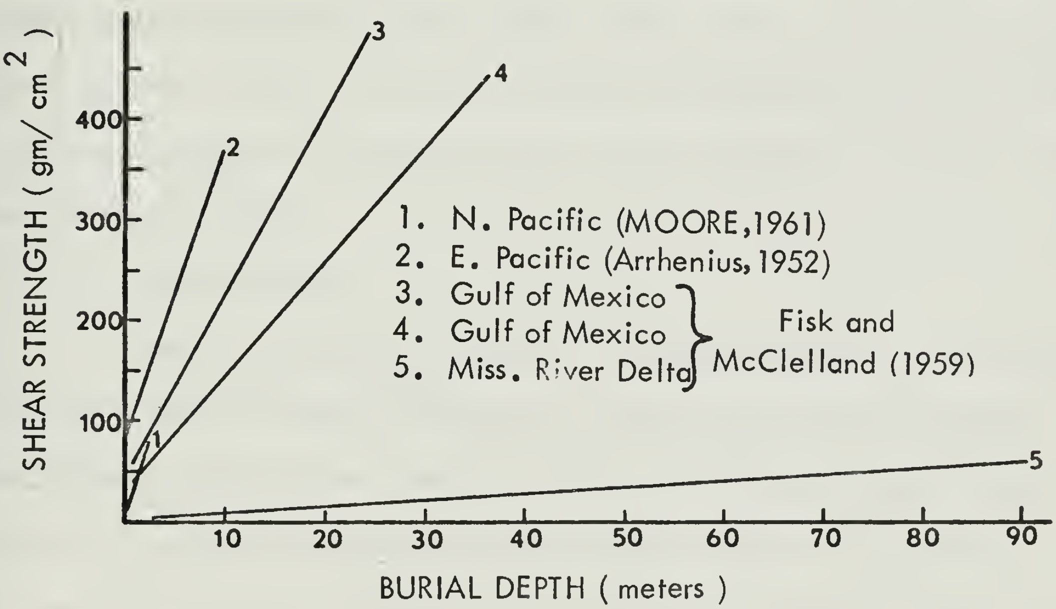


Figure 1. Shear Strength versus Depth for Various Depositional Areas (Moore, 1961)

b. Median Grain Size

The effect of grain size distribution on the shear strength of fine grain sediments is not well defined, however, it does give some measure of the consistency of the material. Trask and Rolston (1951) conducted a comprehensive study of this effect and concluded that for a given water content, the strength increased with an increasing percentage of fine grained clay-sized particles. Analyses of 24 cores from the Hatteras Abyssal Plain by Stiles (1967) demonstrated that mass properties were affected to a greater degree by grain size than any other parameter.

One study of fine grain bay sediments showed that shear strength had a positive correlation with grain size (Keller, 1964). However, since an inverse relationship exists between grain size and water content (Trask and Rolston, 1950) it is probable that the decrease in water content as a result of the larger grain size was the dominant factor in the higher shear strengths which were noted. Though not considered in this study, the mineralogic type of clay for a given grain size is also an important factor (Trask and Rolston, 1951). As the grain size increases, however, the specific type of mineral becomes a less influential factor relative to shear strength (Winslow and Gates, 1963).

c. Water Content

Water content has long been recognized as one of the major factors which affect the shear strength of sediments (Richards, 1962). Trask and Rolston (1950) show that an inverse relationship exists (for specific grain size groups) between water content and the logarithm of shear strength of the San Francisco Bay sediments. A similar result was found by Morelock (1969) for Gulf of Mexico sediments, however, Holmes and Goodell (1964) indicate that a linear relation exists. Richards and Keller

(1962) suggest that it may eventually prove possible to determine shear strength from in-situ values of water content. The water content usually decreases with increased depth in the sediment (Richards, 1962), which equates well with a decrease in the void ratio with increased overburden pressure so as to permit the sediment to hold a lesser quantity of water. In that the void ratio is in turn dependent on grain size (Rominger and Rutledge, 1952) this results in a general dependency of water content on both grain size and depth in the core. A combination of these results verifies an inverse relation between shear strength and water content.

d. Liquid Limit

The liquid limit is the water content, expressed in percentage of dry weight, at which a remolded soil is just capable of resisting a shearing force caused by several sharp impacts. It is generally considered to represent the boundary between the viscous liquid state and plastic solid state of soil. Casagrande (1932) developed the first standardized procedure and test device for liquid limit determination. This method, which forms the basis for American Society for Testing and Materials (ASTM) procedure D-423-66, consists of placing a remolded cake of soil in the cup of the test device (Figure 2) then cutting a groove down the middle of the cake. The crank of the device is then rotated approximately two revolutions per second causing the cup to drop a distance of one centimeter, striking a hard rubber surface with each turn. The liquid limit has been reached when the water content is such that it requires 25 blows of the cup to cause the two halves of the cake to come together over a distance of one-half inch in the groove. This test has developed into one of the standard procedures throughout the world in the soil engineering field. Casagrande (1932) further defines the liquid limit as a measure of the remolded shearing resistance by the following equation:

$$LL = -F \log S + C \tag{2}$$

LL = Liquid limit

F = Flow index (water content range corresponding to the number of blows in one cycle on the logarithm (number of blows) - water content plot)

S = Shearing resistance corresponding to the liquid limit (constant for all soils)

C = Constant.

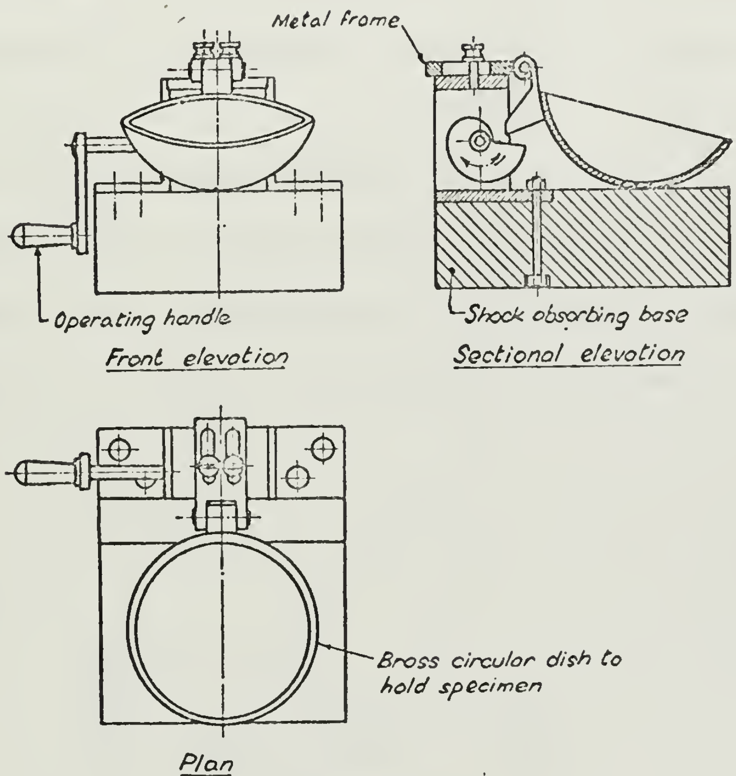


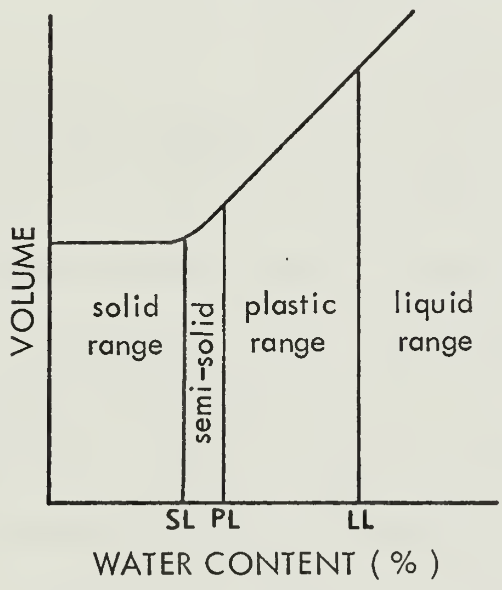
Figure 2. Liquid Limit Device

In spite of the fact that the liquid limit is also defined as a measure of the dynamic shearing strength of soil at a particular water content (Casagrande, 1958), it has not been determined that a significant relation exists between liquid limit and the original shear strength. The inclusion of liquid limit in this study was based primarily on the fact that it has been shown to be a reasonably good measure of the consistency

of a soil (Winslow and Gates, 1963; Skempton, 1944; Rominger and Rutledge, 1952; Seed, et al.,1964a). Thus, at least one term in the equation would account for strength differences in sediments (particularly clays) of varying textural and chemical composition.

e. Plastic Limit

The plastic limit defines the lower boundary of the water content range over which a soil will behave in a plastic manner (with liquid limit as the upper bound, see Figure 3). Below the plastic limit the soil acts as a semi-solid and crumbles easily. Due to the empirical nature of the plastic limit, its true nature is not well understood, however, it has been shown to give a general measure of the toughness of a clay (Casagrande, 1932). Plastic limit is quite sensitive to textural and mineralogic changes (Grimm, 1962; Rominger and Rutledge, 1952; Terzaghi, 1955), and was therefore included as a secondary indication of the sediment consistency.



PL = Plastic limit

LL = Liquid limit

SL = Shrinkage limit

Figure 3. Consistency Limits (Capper and Cassie,1960)

f. Plasticity Index

The Plasticity Index indicates the region over which the sediment behaves plastically (Figure 3), and is defined by the following

equation:

$$PI = LL - PL \tag{3}$$

PI = Plasticity index

LL = Liquid limit

PL = Plastic limit

Plasticity index was not utilized in the analysis for the shear strength prediction equation in that it is a combination of two terms already included. It was employed, however, in determining significant correlations among other properties.

g. Liquidity Index

Liquidity index is expressed by the following ratio which relates the natural water content to the plastic range as defined in Figure 3:

$$LI = \frac{WCO - PL}{PI} \tag{4}$$

LI = Liquidity Index

WCO = Original water content

As is evident from equation (4) a liquidity index between zero and one results when the natural water content is less than the liquid limit. The material is thus in the plastic range. Most marine sediments, particularly those near the sediment-water interface, have a liquidity index greater than one, indicating that they exist naturally in a "liquid" state. Rominger and Rutledge (1952) indicate that liquidity index strongly reflects the loading history of soils by effectively canceling the lithologic influence on water content and plasticity index. Liquidity index was also included in the investigation for the purpose of checking interrelationships with other sediment parameters.

3. Other Investigations

In addition to those parameters analyzed as part of this investigation, other properties have been shown to influence shear strength under specific circumstances.

A comprehensive study of the shallow water sediments of St. Andrews Bay, Florida, showed that the ratio of kaolinite to illite clay was one of three major factors determining the variation in shear strength (Holmes and Goodell, 1964). Trask and Rolston (1950) also comment that the type of clay mineral could be one of the main parameters affecting sediment strength. Analysis of the sediments obtained from the Mohole (Guadalupe site) tends to confirm this theory (Moore, 1964).

It is apparent from data collected at a variety of locations that the average depositional rate should be considered when estimating the bearing capacity of sediments (Moore, 1964). Shallow coastal regions are generally the areas where the depositional rate exceeds the ability of the sediment to consolidate in a normal manner (Figure 1). Therefore, it is not considered to be of particular importance when dealing with deep sea sediments which are deposited much more slowly in a grain by grain fashion.

Calcium carbonate undoubtedly contributes to shear strength as a result of some form of cementation of the individual grains. The exact effect is variable, however both the St. Andrews Bay and Mohole samples displayed a positive correlation between percent $CaCO_3$ and shear strength (Holmes and Goodell, 1964; Moore, 1964). No attempt was made to correlate percent carbonate and shear strength in this report due to the inaccuracy of the limited data available (M. C. Hironaka, personal communication).

Finally, the porosity of sediments has been reported to exhibit an inverse relation with shear strength (Moore ,1964). This is a natural result of a decrease in void volume as the overburden pressure increases.

II. REPRODUCIBILITY OF PARAMETERS

A. DISCUSSION

In order to fulfill the primary objective of this study, the original values of all of the index properties included as terms in the shear strength prediction equation must be reproducible from partially dried sedimentary material. Initial interest in this regard was centered around liquid limit and its correlation to shear strength. Detailed tests were therefore conducted to determine to what extent the "original" value could be reproduced after the sediment had been thoroughly air dried.

B. LIQUID LIMIT

1. Background

Liquid limit has long been recognized as a useful empirical measure of the classification and consistency of soils (Casagrande, 1948). Considerable study has centered around the variables affecting liquid limit, and also the testing and rehydration procedures. Russell and Mickle (1970), and Rominger and Rutledge (1952) have briefly summarized the results of these investigations.

The liquid limit of soils is currently determined following ASTM procedure D-423-66, utilizing the Casagrande Liquid Limit device (Casagrande, 1932). The steps necessary for preparation of the sample for this test, as specified in ASTM procedure D-421-58, require a complete air drying and then thorough breaking-up of all aggregations prior to rehydration to the liquid limit. Although the values obtained from terrigenous soils by this method were less than those determined from natural un-dried samples (Casagrande, 1932; Winslow and Gates, 1963), the relative percentage difference was not excessive. Marine sediments present a much different situation,

in that they exist in the natural state at water contents far in excess of the liquid limit. For convenience, and in accordance with other methods (Lambe, 1951), many laboratories perform the liquid limit test on marine sediments without going through the drying process, as sufficient desiccation may take several days, or even weeks to complete. Liquid limits determined in this manner are thus representative of their in-situ values. Since the majority, if not all, of the values used in this analysis were obtained from undried samples, it was necessary to investigate the effect of a complete air drying on the reproducibility of the original liquid limit.

2. Test Procedures

The 20 sediment specimens used in this experiment were obtained from four cores collected in a water depth of approximately 7200 feet at a location 40 miles west of Monterey, California. A gravity corer with a PVC liner and 420 pounds of weight was used to obtain these samples. Immediately after removal from the corer, the liners were capped and placed in a barrel of sea water to prevent desiccation. Within two weeks after collection, the cores were cut apart and tested without drying. The values obtained were thus considered to be valid in-situ or "original" values of liquid limit.

After this first test, the samples were placed in open glass containers and allowed to dry at room temperature for a period of approximately four months. The hardened material was then rehydrated with distilled deionized water and allowed to "soak" for 24 to 72 hours. Distilled deionized water was used on the assumption that this represented as closely as possible the water which had evaporated during drying and to avoid any complications which might arise from exchangeable ions. It was theorized that the salts in the original sea water would again redissolve in the distilled water.

The excessive rehydration time was employed to assure that the sediment had absorbed as much water as possible. Winslow and Gates (1963) determined that the best results are obtained if a 24 hour rehydration time is used when attempting to reproduce the Atterberg limits of dried soils. Upon completion of rehydration, the soft wet aggregates were broken up and the sediment thoroughly remolded to assure homogeneity prior to conducting the liquid limit test.

Upon completion of the second set of tests, the sediment was placed under an exhaust vent and again allowed to air dry. Complete drying in this manner required from one to three days. When the specimens were thoroughly dry, they were broken up in a motar, as required by ASTM procedure D-421-58, and rehydrated in the same manner as described above. At the end of the rehydration period, each sample was vigorously mixed and then tested for liquid limit.

3. Test Results

As was anticipated, after the air drying process, the liquid limits were lower than the values obtained prior to drying. The high percentage reductions involved, on the order of 30% to 40%, were however, totally unexpected (Table I). Casagrande (1932) does note that organic colloids are partially destroyed upon drying, but a reduction in the liquid limit value from this cause is most significant when the material has been oven dried. From the initial liquid and plastic limit values, all specimens analyzed in this experiment plotted below the "A" line on the plasticity chart (Casagrande, 1948), suggesting that they were organic in nature (Figure 4). Casagrande presents data showing a decrease of 28.8%, 26.4%, and 15.9% in the liquid limits of three oven dried samples. Presumably the percent decrease would have been less had the samples been air dried.

TABLE I

LIQUID LIMIT TEST RESULTS

CORE	Interval in.	Original Liquid Limit	Liquid Limit After One Drying	Liquid Limit After Two Dryings
CH-2	0-3	130.0	82.0	76.0
	12-15	127.0	82.4	77.4
	24-27	135.0	85.2	76.2
	36-39	128.0	80.8	75.1
	48 51	119.0	85.0	74.6
	60-63	107.0	78.6	71.2
HH-1	0-3	131.3	87.4	74.9
	12-15	128.5	87.6	74.7
	24-27	134.3	89.4	79.2
	36-39	117.5	85.7	75.1
	48-51	117.8	83.8	71.5
NR-1	0-3	126.9	87.3	78.4
	12-15	114.3	84.2	75.1
	24-27	123.8	84.0	77.1
	36-39	119.9	81.8	71.9
	48-51	107.5	76.3	73.7
SW-1	0-3	106.8	83.4	78.5
	12-15	187.0	87.8	77.1
	24-27	65.5	84.5	81.0
	36-39	102.5	102.0	74.3

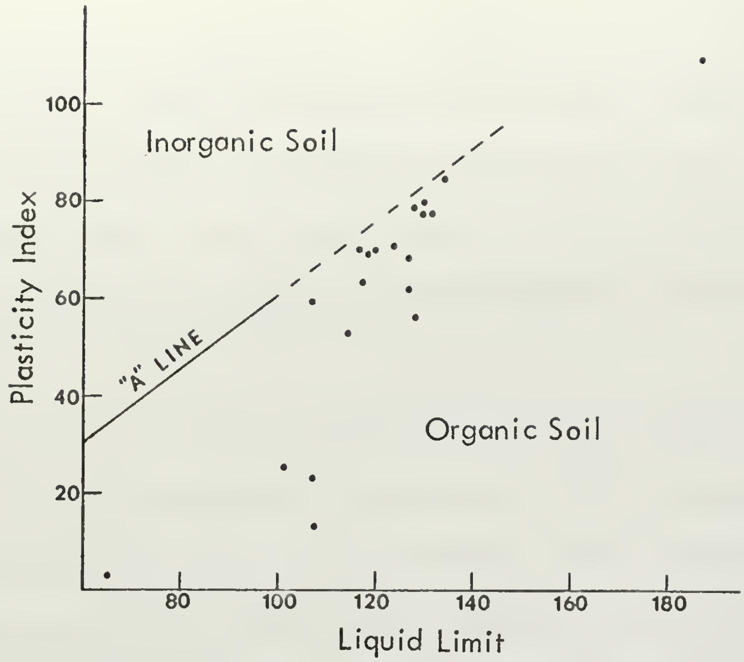


Figure 4. Plasticity Chart for Sediment Samples Used in the Liquid Limit Tests

Winslow and Gates (1963) conducted comprehensive tests on drying and rehydration methods for both organic and inorganic soils. They observed virtually no decrease in liquid limits for both types of soil after a 24 hour rehydration period. Two soils which contained montmorillonite clay did exhibit a decrease in liquid limit of 18.5% and 13% even after rehydration for 24 hours. It was also noted that up to a 20% reduction in liquid limit can be expected if the rehydration period is less than 30 minutes. As may be seen from Table I, the liquid limits obtained from the second and third tests were distributed over a much narrower range than were the original values. Possibly this may be attributed to the inexperience of the operators who determined the initial values. All subsequent liquid limits (in the second and third series) were performed by more experienced personnel.

In remolding the material after the first drying and rehydration it proved easy to break the large wet aggregates apart, but considerable

mixing was required to return it to a condition similar to the original smooth consistency. This was not nearly as great a problem in the final group of tests where the dried sediment had been ground to a fine powder prior to adding water. The narrow range of values appears to support the fact that the material was somewhat more homogeneous in the third series of tests.

One difficulty with the procedure involving grinding is that liquid limit has a fairly high negative correlation with median grain size. Perhaps this pulverizing of deep sea sediments, which are extremely hard when dried, may result in erroneous values depending on the degree of grinding.

Although it is evident from this experiment that the liquid limit determined from a dried marine sediment will be lower than the in-situ value, the degree of this reduction is uncertain. In effect, the liquid limit of oceanic sediments cannot presently be considered to be a reproducible quantity.

The multiple correlation coefficient between the second test values and the original liquid limits for three of the four cores (the initial values for the fourth core were erroneous) was .662. It is therefore quite possible that a relation may eventually be developed which will enable the computation of in-situ liquid limits from the combined values of organic content and the liquid limit as determined after the sediment has dried.

C. OTHER PARAMETERS

1. Depth in the Core

The usual practice when storing sediment cores is to mark the depth intervals on the container itself. If a certain section is removed for testing, a dummy plug is inserted in its place, keeping all material in proper relative position. Therefore, it should be possible to determine the depth interval of a specimen with little difficulty.

2. Water Content

With the exception of the results of analysis conducted as part of this investigation (Section IV), there is presently no method of reproducing the in-situ water content. An investigation is currently being conducted at the Naval Postgraduate School on a correlation between water content and salt content of marine sediments. If successful it will then be possible to determine the original water content by chemical means.

3. Median Grain Size

According to ASTM procedure D-421-58 air dried samples should be broken apart in a mortar prior to grain size analysis. Lambe (1951) specifies that the sample should not be dried, particularly if clay is present, as the individual particles may undergo a change in size or shape. In dealing with marine sediments, satisfactory reproducible results appear to be obtained if the specimen has not completely dried. If the material has dried, it is presumed best to rehydrate the sediment over a period of several days until it is fluid enough to conduct the mechanical analysis. In this manner there will possibly be little or no damage to the individual grains. Breaking-up in the dry state as specified by ASTM procedure D-421-58 is not recommended for marine sediments.

4. Plastic Limit

Since the plastic limit is also affected by the consistency of the soil, it is assumed that it is reproducible to approximately the same degree as is the liquid limit. This assumption is based on only a limited amount of research conducted on this subject (Casagrande, 1932; Winslow and Gates, 1963).

III. DATA

A. INITIAL REQUIREMENTS AND LIMITATIONS

The nature of this study necessitated that the data acquisition be limited to those cores which had been tested for nearly all their engineering parameters. The liquid limit and median grain size were of particular interest, hence such data was not useful unless these two properties had been determined. Following these requirements, data relative to approximately 200 cores was obtained from four sources. The majority of this was provided by the Naval Civil Engineering Laboratory in Port Hueneme, California. Additional information was also obtained from technical reports by Richards (1962) and Keller (1964), and from the National Oceanographic Data Center.

The following two additional limitations were imposed on this initial data. First, in order to truly represent a deep sea environment, only those cores taken in water deeper than 6000 feet were considered. Although it is recognized that portions of the continental slope may thereby be included, such a depth was selected based on the availability of data and also on the assumption that sediment composition does not vary significantly between 6000 feet and the deeper abyssal plains. Additionally, deep ocean sediments are not apt to be over-consolidated and therefore very few abnormally high shear strength layers will exist to distort the results. Smith (1962) provides a discussion on the merits of classifying various different provinces of the ocean according to water depth. In view of the extremely fine grain size of most deep sea sediments, 0.01 millimeters (Wentworth fine silt) was established as the upper limit of median grain size for each core specimen included in the analysis. Samples having a greater median grain size invariably contained a high percentage of coarse silt and sand, and were

therefore assumed to be non-representative of true deep sea sediments. The above restrictions resulted in 114 cores being included in the final analysis, from which a total of 701 data points were derived. Considerable effort was required to accumulate this data, and it is probable that it represents the majority, if not all, of the existing deep sea sediment cores in the United States on which a full suite of engineering properties have been evaluated. The actual data for those parameters utilized is tabulated in Appendix I.

B. GENERAL

Tables II, III and IV and Figure 5 through Figure 9 give geographical position, depth, and other general information about the cores utilized in this study. The exact locations of 33 of these cores was not available, hence only their approximate position is listed. The "Data Points" column refers to the number of intervals in each core that met the initial established requirements. For ease in data handling and presentation, each core was assigned a reference number. This number is used in identifying the core locations on Figures 5 through 9. The tables also identify the cores according to their original designation as assigned by the collecting agency.

In order to give a more complete picture of the ranges and statistical parameters of each of the engineering properties analyzed, Table V and Figure 10 through Figure 15 were prepared. It will be noted that the plastic limit, plasticity index, and liquidity index were determined on 573 of the samples studied.

It is of particular interest that several of the histograms, notably that for water content, approach a normal distribution. The histogram for liquid limit values are evenly distributed, though the histogram is more peaked than

normal, and the high concentration of median grain sizes around 9.5 φ is quite apparent. As may be seen in Figure 10, shear strengths of less than 90 gm/cm^2 obviously predominate in these cores.

TABLE II

POSITIONS OF NAVAL CIVIL ENGINEERING LABORATORY CORES

Reference Number	Original Designation	Depth (FT)	Data Points	Position Longitude	Latitude
1 to 18	BS-A Series	9780/13,300	120	See Fig. 8	
19 to 41	BS-B Series	14,150/15,450	197	See Fig. 8	
42 to 55	BS-C Series	11,700/19,200	60	See Fig. 9	
56	C6-C1	8100	8	41°44'N	64°58'W
57	SM-1	6000	6	33°52'N	120°35.8'W
58	SM-2	6000	7	33°52.2'N	120°36.0'W
59	9-1	11,400	7	33°46.8'N	121°50.9'W
60	9-2	11,650	8	33°49.5'N	121°49.9'W
61	9-3	11,700	8	33°48.9'N	121°51.5'W
62	9-4	11,700	7	33°47.9'N	121°52.4'W
63	10-1	12,100	1	32°00.1'N	120°39.8'W
64	10-2	12,100	7	32°01.1'N	120°38.8'W
65	10-3	12,200	7	31°58.2'N	120°38.8'W
66	PMR-1	8,700	4	33°49.3'N	121°09.4'W
67	A	17,100	2	N. of Christmas Island*	
68	B	18,900	3	Tokalau Trough*	
69	C	18,900	2	Tonga Trench*	
70	D	14,400	3	S. Fiji Basin*	
71	E	15,900	3	Tasman Abyssal Plain*	
72	F	14,400	5	Coral Sea Basin*	
73	FT	14,400	5	Coral Sea*	

Reference Number	Original Designation	Depth (FT)	Data Points	Position Longitude	Latitude
74	G	14,700	4	Solomon Basin*	
75	H	13,200	6	Solomon Basin*	
76	K	10,800	5	W. Timor Sea*	
77	L1 and LT1	18,600	10	W. of Java Trench*	
78	LT2	18,600	5	W of Java Trench*	
79	M	21,600	5	Java Trench*	
80	N	14,400	8	W. of Sumatra*	
82	O	13,800	6	Indian Ocean*	
81	OT	13,800	4	Indian Ocean*	
83	P and PT	10,500	5	Bay of Bengal*	
84	Q and QT	9,600	4	Andaman Basin*	

*Exact positions for these cores were not available

TABLE III

POSITIONS OF CORES FROM A TECHNICAL REPORT
(Richards, 1962)

Reference Number	Original Designation	Depth (FT)	Data Points	Position Longitude	Position Latitude
85	D-1p	8,400	1	30°N	75°W*
86	E-46	6,600	4		
87	E-47	6,600	4	45°N	57°W*
88	E-48	7,200	2		
89	F-6	7,440	13		
90	F-10	8,040	4		
91	F-11	8,040	7		
92	F-12	7,940	5	42°N	65°W*
93	F-13	7,920	3		
94	F-14	7,850	8		
95	F-15	7,920	7		
96	F-16	7,920	3		

*Exact positions for these cores were not available

TABLE IV

POSITIONS OF NATIONAL OCEANOGRAPHIC DATA CENTER CORES

Reference Number	Original Designation	Depth(FT)	Data Points	Positions Longitude	Latitude
97	31884-2A	14,950	1	16°55'N	179°06'E
98	31884-4A	18,750	2	11°02'N	179°58'W
99	31884-7A	19,150	1	01°57'N	179°46'W
100	31884-19A	15,450	1	02°00'N	160°00'W
101	BS-1	12,100	3	24°18'N	86°20'W
102	BS-2	12,100	2	24°25'N	85°39'W
103	BS-3	6,230	4	24°45'N	85°49'W
104	Proj.101 BS-1	8,950	6	28°02'N	87°08'W
105	Proj.101 BS-2	11,100	14	25°09'N	88°51'W
106	Proj.101 BS-3	9,100	9	26°26'N	87°40'W
107	Proj.101 BS-4	12,000	7	23°20'N	93°31'W
108	Proj.101 BS-5	12,500	12	25°02'N	91°03'W
109	AGS-30 BS-1A	11,200	3	28°59'N	70°30'W
110	AGS-30 BS-12	7,200	7	20°20'N	95°14'W
111	AGS-30 BS-13	12,000	7	23°10'N	94°12'W
112	AGS-30 BS-14	8,950	7	23°09'N	96°10'W
113	AGS-30 BS-18	11,600	12	24°42'N	89°34'W
114	AGS-30 BS-19	11,200	10	24°44'N	89°34'W

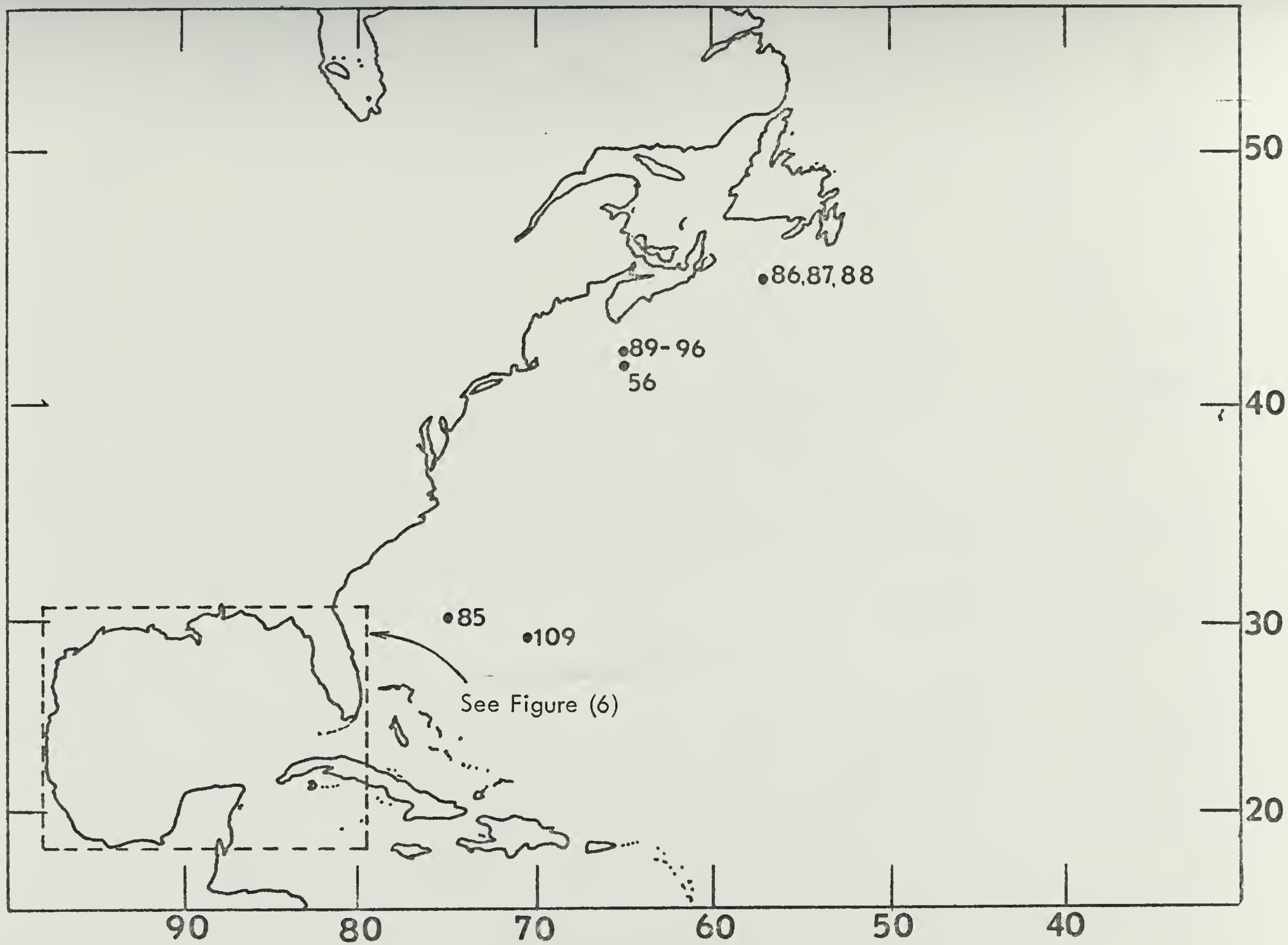


Figure 5. Atlantic Ocean Core Locations

Figure 6. Gulf of Mexico Core Locations

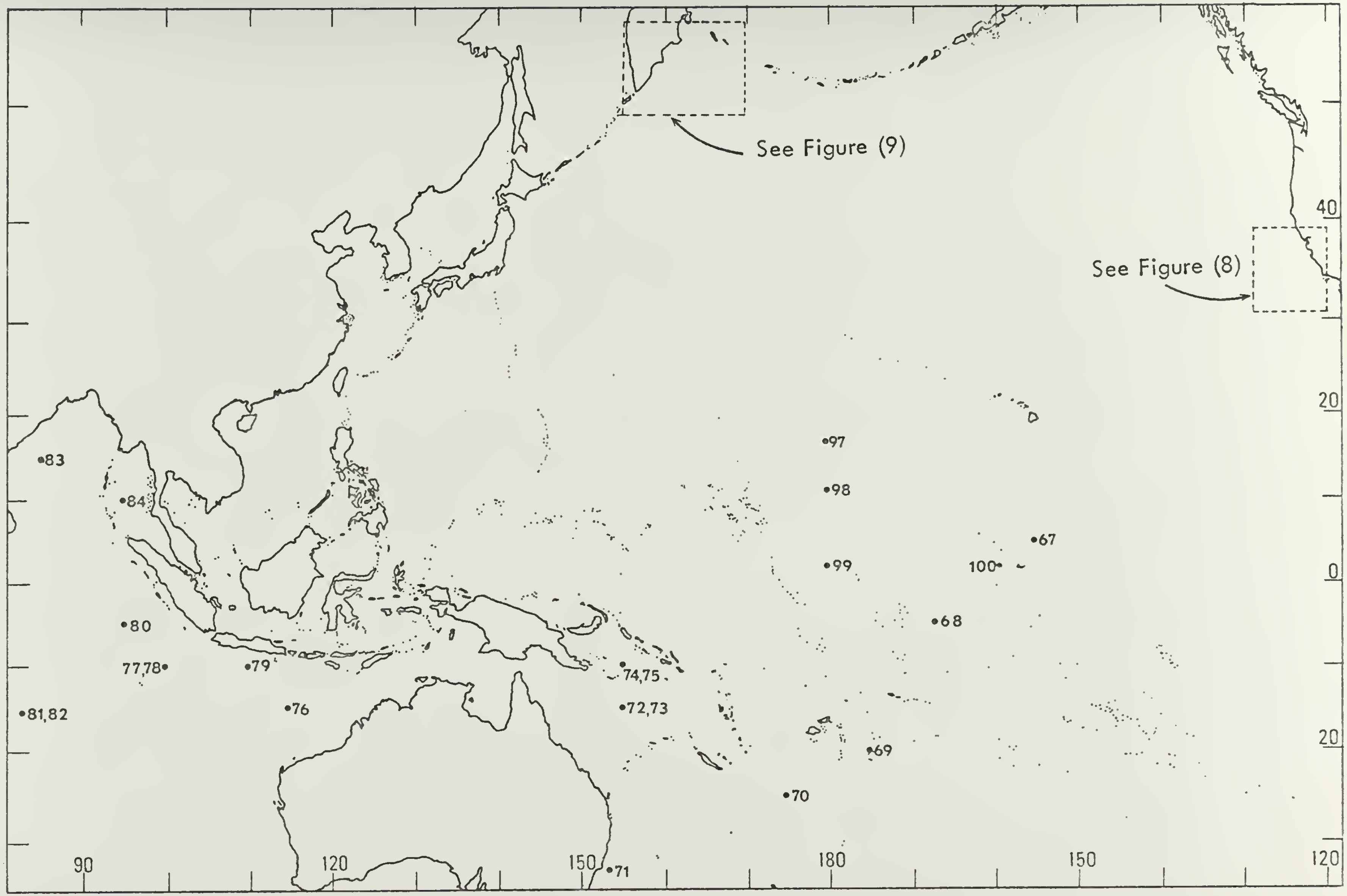


Figure 7. Pacific Ocean Core Locations

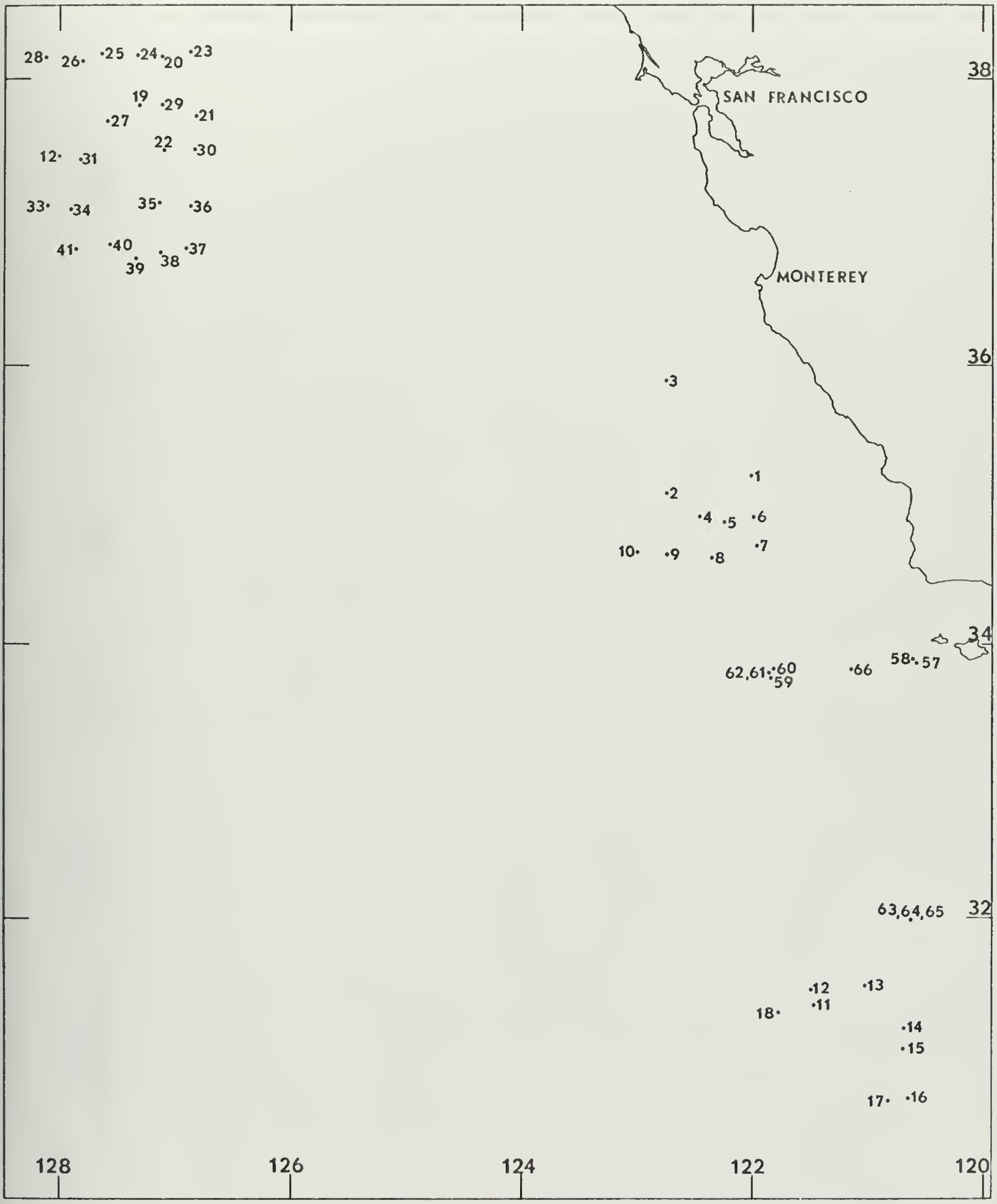


Figure 8. East Pacific Core Locations

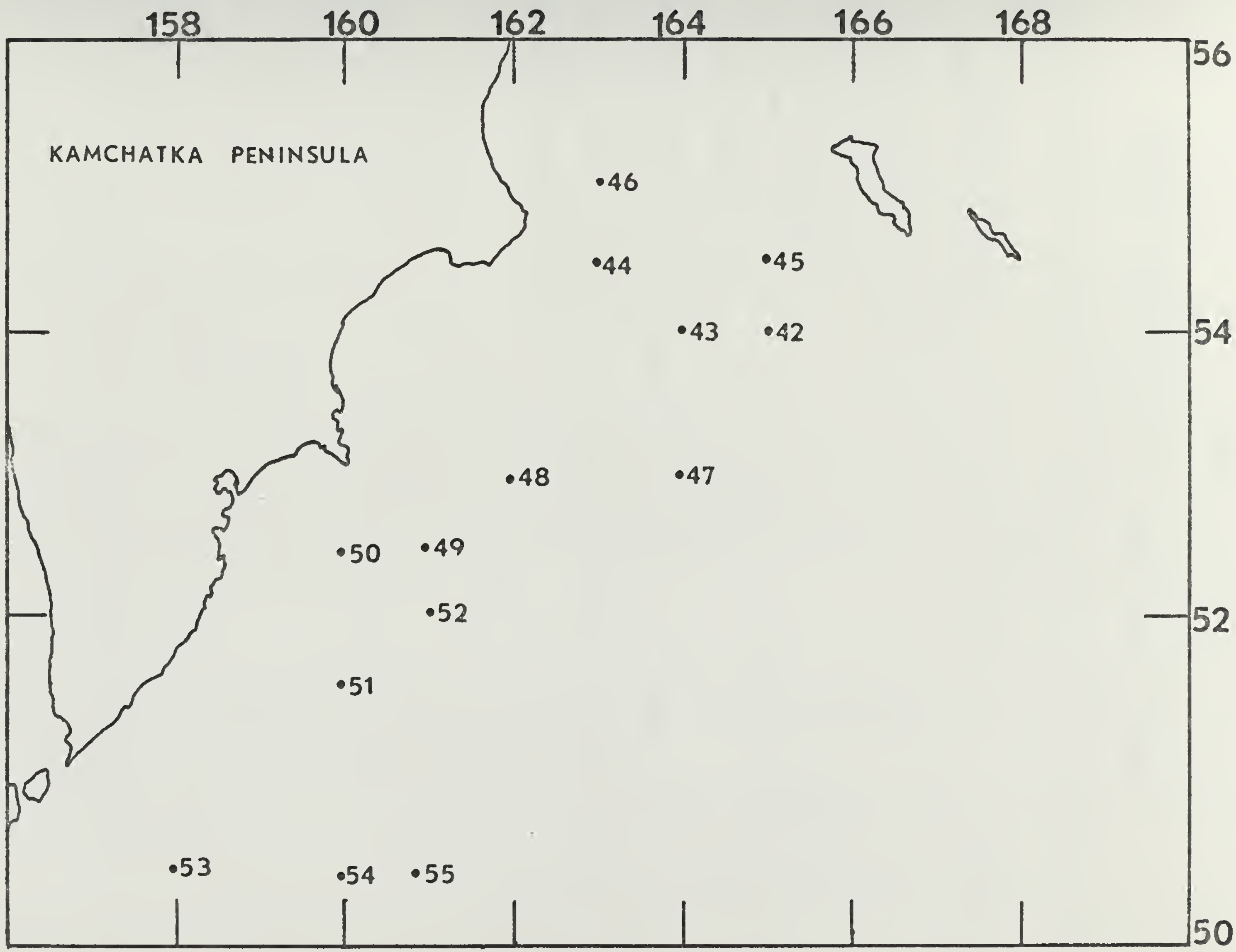


Figure 9. Kamchatka Peninsula Core Locations

TABLE V

GENERAL SEDIMENT PARAMETER STATISTICAL INFORMATION

SEDIMENT PROPERTY	Number of Observations	Mean	Standard Deviations
Shear Strength (gm/cm^2)	701	43.4	21.4
Water Content (%)	701	128.0	45.6
Liquid Limit (%)	701	93.7	24.8
Plastic Limit (%)	573	39.4	13.5
Median Grain Size (Ø)	701	9.1	1.0
Plasticity Index (%)	573	52.9	18.9
Liquidity Index (%)	573	1.72	.802

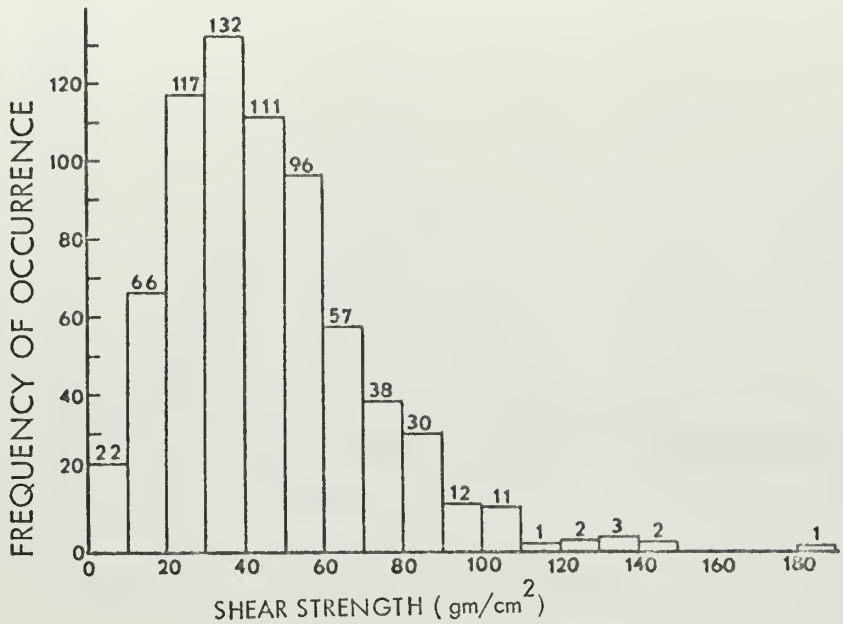


Figure 10. Shear Strength Histogram

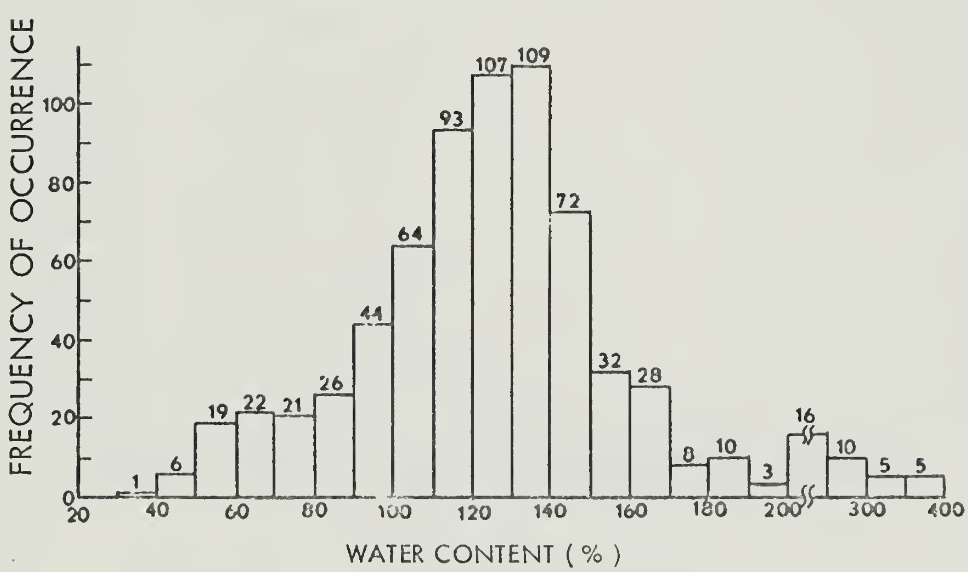


Figure 11. Water Content Histogram

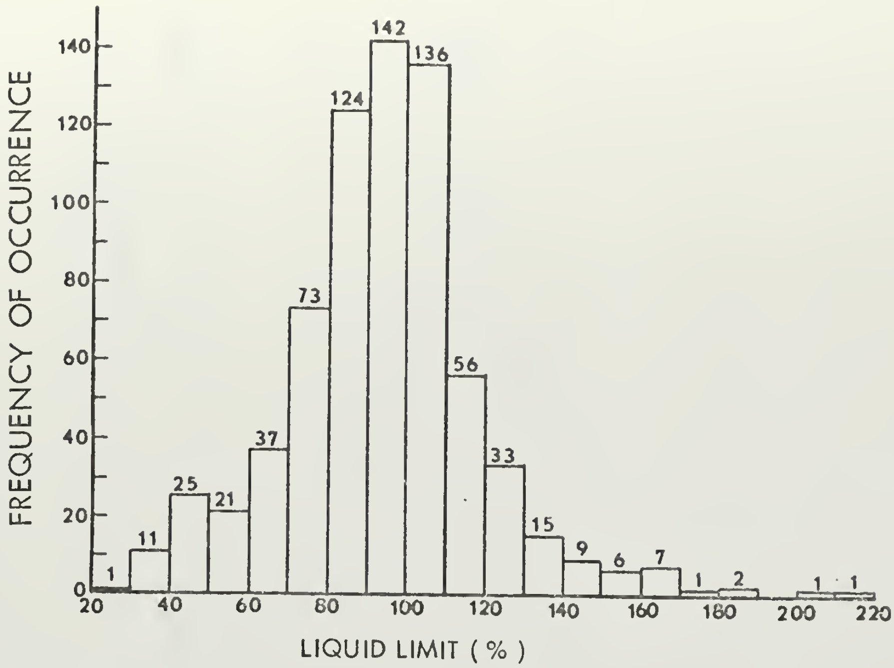


Figure 12. Liquid Limit Histogram

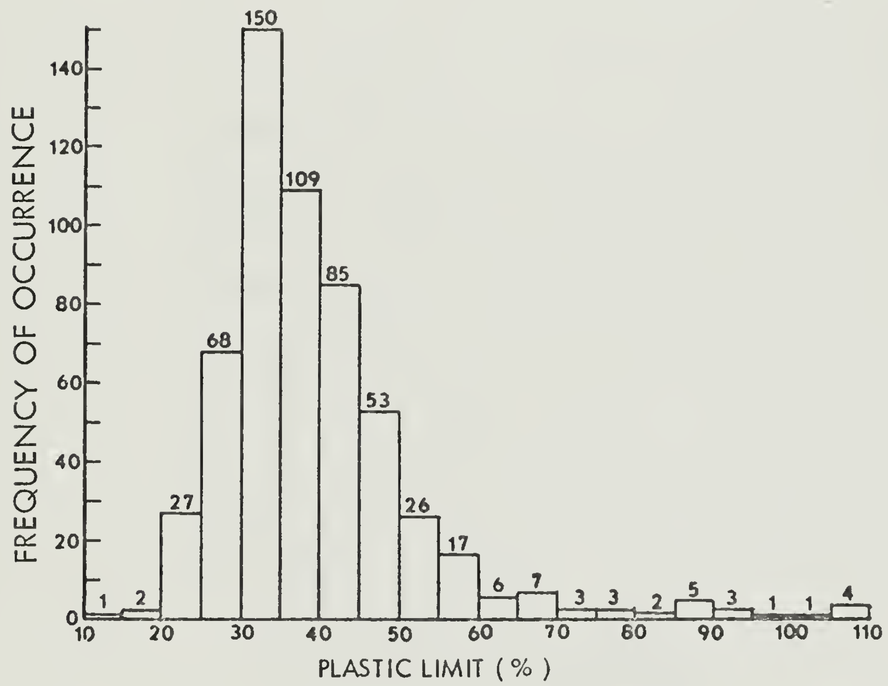


Figure 13. Plastic Limit Histogram

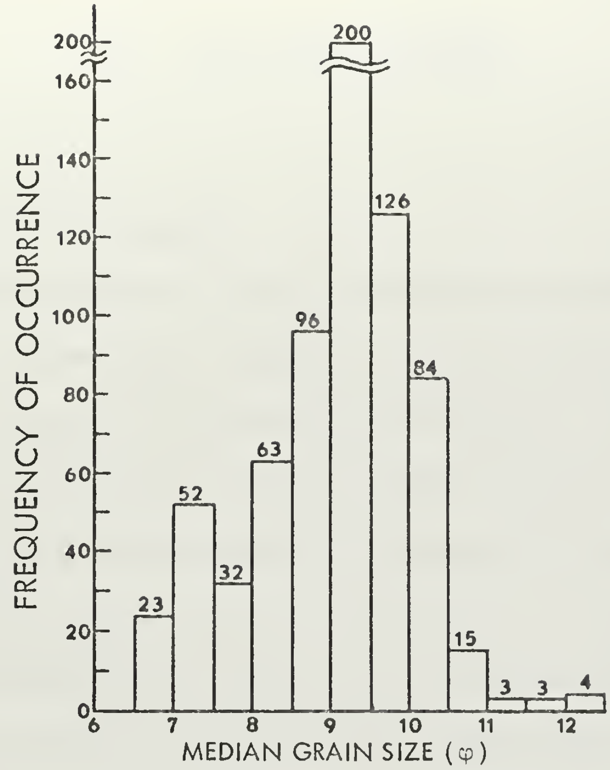


Figure 14. Median Grain Size Histogram

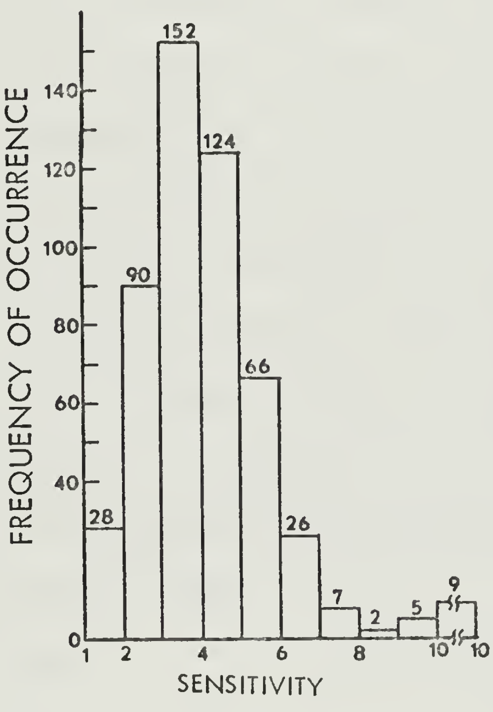


Figure 15. Sensitivity Histogram

IV. STATISTICAL ANALYSIS

A. METHOD

1. Regression Analysis

Stepwise multiple linear regression was employed in the determination of both the final shear strength prediction equation and significant correlations between other engineering parameters. The Naval Postgraduate School IBM-360 FORTRAN library program BMDO2R was used for this analysis. This is one of the Bio-medical series regression programs developed by the University of California, Berkeley (Dixon, 1970). Stepwise multiple regression was selected in that none of the variables examined were considered to be completely independent of the other engineering properties. Utilizing this procedure, the data is analyzed to determine which parameter explains the greatest portion of the variability in the dependent variable. The program continues in steps, successively selecting the next most important variable to be added to the regression equation until all the variables which meet specified requirements have been included. The term chosen in the final step thus explains the least percentage of the variability. Holmes and Goodell (1964) present a discussion on the merits and limitations of applying regression techniques to natural sediment systems. In the analysis which follows, R is defined as the multiple correlation coefficient. That portion of the variance of the dependent variable which is accounted for by the estimated linear regression on the independent variables is denoted by RSQ (Hays and Winkler, 1970).

2. Confidence Limits

Limits for the 95% confidence level have been drawn on the shear strength and water content plots (Figure 16 and Figure 18). These limits

indicate the approximate accuracy of the predicting equations. If all computed values were exactly equal to the true values, every point would fall on the 45° line, and hence the confidence limits would have no meaning. Where a scatter of data exists, however, the confidence limits define the percentage of points which fall both within, and without, the particular bounds. For the 95% level, 5% of the points will fall somewhere outside the confidence limits. In utilizing the respective equation, it can be assumed that there is a 95% probability the computed value will be within the limit bounds.

B. STATISTICAL RESULTS

1. Shear Strength and Water Content Equations

Approximately 60 separate regression analyses were conducted to establish the optimum shear strength prediction equation. With the exception of median grain size, which proved too insignificant for inclusion, correlation coefficients between each parameter and shear strength were highest when the logarithm of shear strength was used as the dependent variable (Table VI). The column titled "Equation Multiple Correlation Coefficient" in Table VI refers to the coefficient obtained when the four most significant variables were included in the respective shear strength regression equation. When the natural value of shear strength was used as the dependent variable, liquidity index replaced liquid limit in the equation. It is of interest to note that liquid limit did not prove particularly significant in any equation unless water content was included as one of the parameters. The equation derived which explains the maximum variation of shear strength is as follows:

$$\mathrm{Log(SS)} = 1.866 + 0.0023(\mathrm{LL}) - 0.597(1/\mathrm{D}^{.3}) - 0.00454(\mathrm{WCO}) + 0.00672(\mathrm{PL}) \quad (5)$$

TABLE VI

SHEAR STRENGTH CORRELATION COEFFICIENTS

DEPENDENT VARIABLE	INDEPENDENT VARIABLES								MR
	WC	LL	PL	D	DM	φ	PI	LI	
Shear Strength (gm/cm^2)	-.318	-.119	-.080	.259	-.298	-.215	-.106	-.266	.506
Logarithm (Shear Strength)	-.374	-.177	-.139	.312	-.375	-.175	-.140	-.267	.558

WC = Water Content (%)

LL = Liquid Limit (%)

PL = Plastic Limit (%)

D = Depth in the core (cm)

DM = $1/D^{.3}$

φ = Median Grain Size (φ units)

PI = Plasticity Index

LI = Liquidity Index

MR = Equation Multiple Correlation Coefficient

SS = Shear strength (gm/cm^2)

LL = Liquid limit (%)

D = Depth in the core (cm)

WCO = Original water content (%)

PL = Plastic limit (%)

True versus computed values (using equation 5) of shear strength are plotted in Figure 16. Though the 95% confidence limits are a bit wide, additional data will undoubtedly reduce the variability.

The depth term in equation (5) differs considerably from the linear relation reported by Arrhenius (1952), Bjerrum (1954), Richards (1961), Moore (1964), and others. The non-linear manner in which sediment compacts, suggests that a depth-shear strength relationship is also probably non-linear. An extensive amount of numerical analysis was therefore conducted to determine the highest correlation between the two parameters. In every comparison with logarithmic or natural values of shear strength, the term $1/D^{.3}$ proved to have the greatest correlation coefficient (Table VII). When this term was included in a multiple regression, the significance (increase in RSQ) of the linear depth term decreased to nearly zero.

TABLE VII

CORRELATION COEFFICIENTS FOR DEPTH IN THE CORE

Shear Strength Relation	D	$1/D^{.3}$	$D + 1/D^{.3}$
Shear Strength (gm/cm^2)	.276	-.282	.299*
Logarithm (Shear Strength)	.313	-.343	.354*

*Multiple correlation coefficient

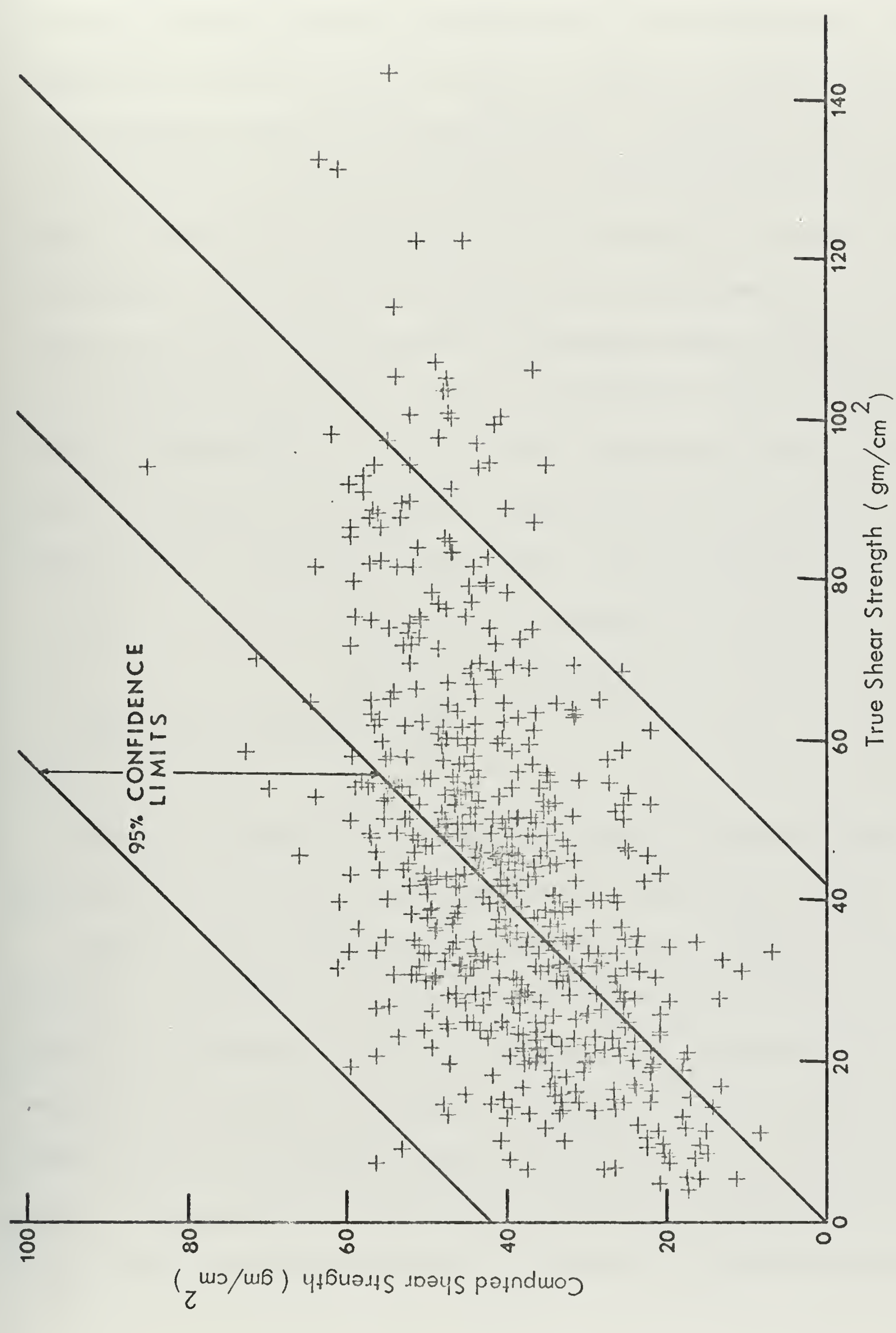


Figure 16. True versus Computed Shear Strength

As noted previously, the depth term exhibited a higher correlation coefficient when compared with the logarithm of shear strength. Computed strength, utilizing the most significant depth relationship, and actual strength for a typical core are plotted in Figure 17, together with data from Arrenhenius (1952) and Richards (1961). It should be noted that the $1/D^{.3}$ term exerts a measurable influence on the strength-depth relationship to a depth of only approximately 60 centimeters. This is the portion of a sediment column which is undergoing the greatest amount of consolidation, and as expected the increase in strength exceeds a linear rate. Below this depth, the rate of increase is essentially linear, as observed by Arrhenius (Figure 17). It was also very interesting to note the similarity between the linear shear strength - depth relationship developed by Arrhenius (1952) and that calculated in this study. The two equations are respectively:

$$SS = 55.0 + 0.00143(D) \qquad (6)$$

$$SS = 36.2 + 0.00142(D) \qquad (7)$$

SS = Shear strength (gm/cm^2)

D = Depth (cm)

Though the slopes of the two relationships are virtually identical, the reason for the difference in the constant terms is not evident.

Original water content values were utilized in the derivation of equation (5). Though this is presently not a reproducible quantity, the true values were included in the first analysis on the assumption that it may eventually be possible to determine the original water content of dried marine sediments by chemical means (Section II.C.2). To solve the immediate problem of determining a value of water content to be employed in equation (5), a second regression analysis was conducted to establish correlations

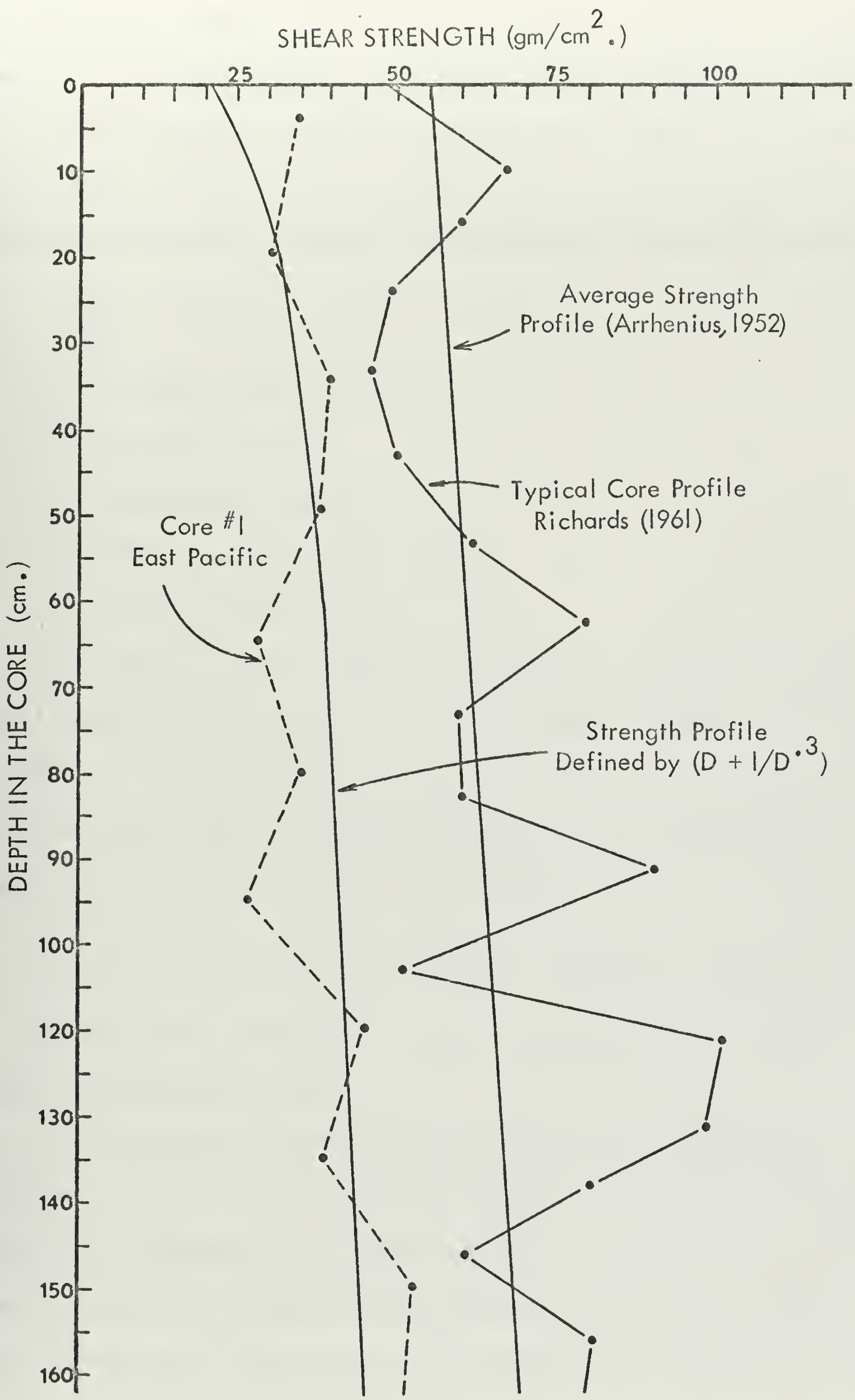


Figure 17. True and Computed Shear Strengths vs. Depth in the Core

between water content and the other properties. Results of this analysis indicate that water content itself may be predicted with a farily high degree of accuracy (multiple correlation coefficient = .881) on the assumption that liquid limit, plastic limit and median grain size are reproducible quantities. Utilizing the available data, the water content prediction equation is:

$$WCC = 0.689(LL) + 1.648(PL) - 0.0752(D) + 7.74(\varphi) - 67.65 \quad (8)$$

WCC = Computed water content (%)

LL = Liquid limit (%)

D = Depth in the core (cm)

φ = Median grain size (phi units)

PL = Plastic Limit (%)

The grain size and depth terms of equation (8) account for slightly over three percent of the total variability of water content. Since grain size analysis is a time consuming laboratory process, this term may be ignored with but little loss in accuracy. The resulting equation then takes the form:

$$WCC = 0.927(LL) + 1.336(PL) - 0.0718(D) - 7.742 \quad (9)$$

This equation accounts for slightly over 75% of the variability of water content (Figure 18).

In order to give a more valid picture of the predictability of the value of shear strength, the shear strength regression was re-run with equation (8) substituted for water content in equation (5). Although the overall significance of the equation was reduced by seven percent, it was still considerably higher than if no water content term were included.

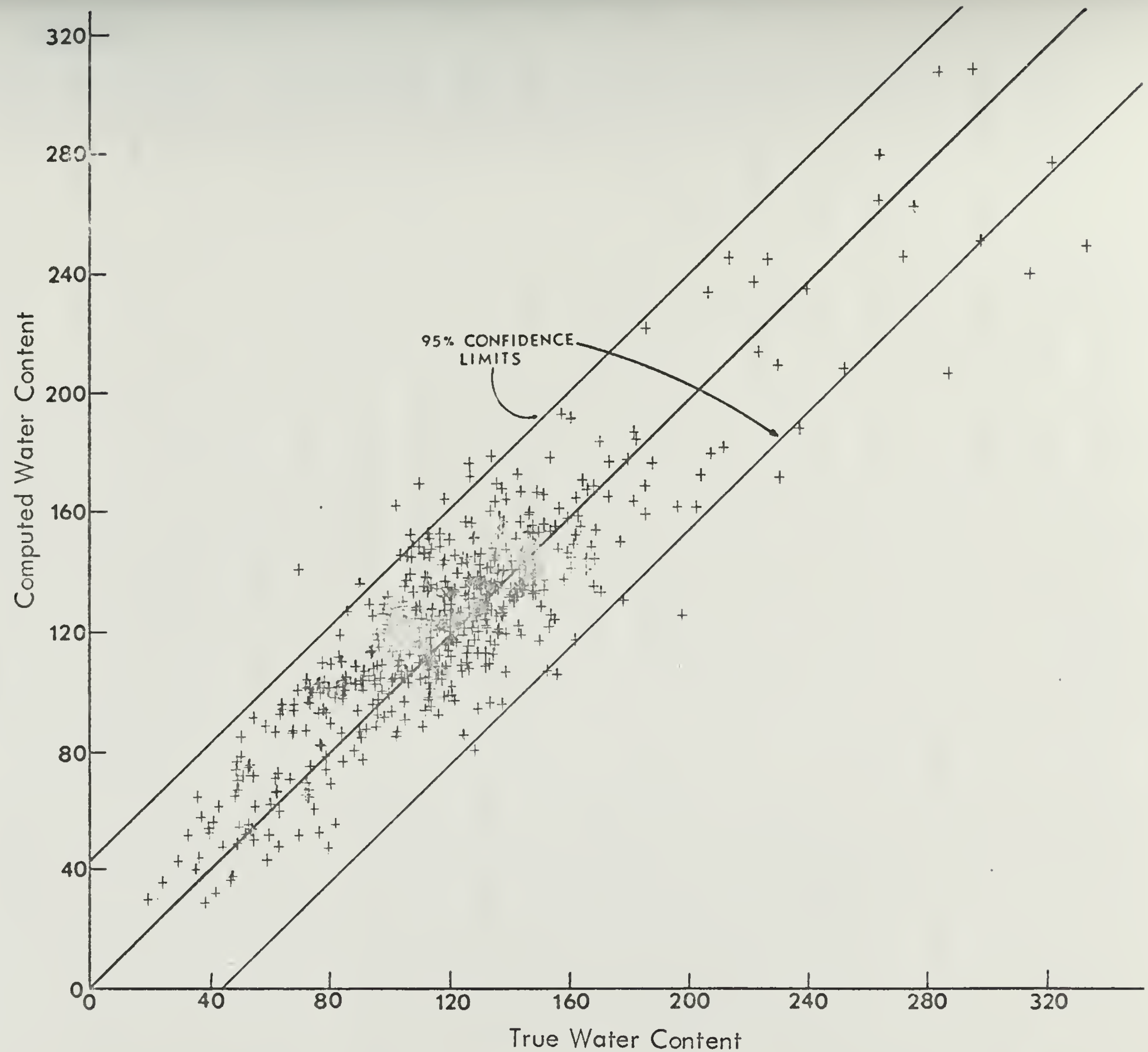


Figure 18. True versus Computed Water Content

2. Other Correlations

In the process of analysis of the data, several additional interesting relationships between the sediment parameters were investigated.

a. Liquidity Index - Logarithm Sensitivity

Bjerrum (1954) briefly discusses a relationship between the logarithm of sensitivity[1] and the liquidity index of Norwegian marine clays. Richards (1962) presents similar results for various Atlantic Ocean sediments. In the case of the first of these studies, the material investigated (while marine in origin) had been uplifted and was no longer in its original saturated condition. The data of Richards is too sparse to establish a reliable relationship. A regression analysis was therefore conducted on the data from 509 samples (representing all of the samples for which sensitivity values were available), to see if sensitivity was determinable from liquidity index. The regression initially proved to be insignificant, until as suggested by Richards, the regression line was forced through the origin (Figure 19). The correlation coefficient then increased substantially, and the slope of the regression line proved to be virtually identical to the average of the lines determined by Richards (1962) from data obtained in his areas E and F in the North Atlantic Ocean.[2]

The usefulness of this relationship lies in the fact that if the original water content, liquid limit, and plastic limit of a sediment sample can be measured, equations (3) and (4) and the regression line from Figure (9) may be used to obtain the sensitivity. It is realized that these results

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[1]Ratio of true to remolded shear strength.

[2]The majority of Richard's data used in this study were from areas E and F.

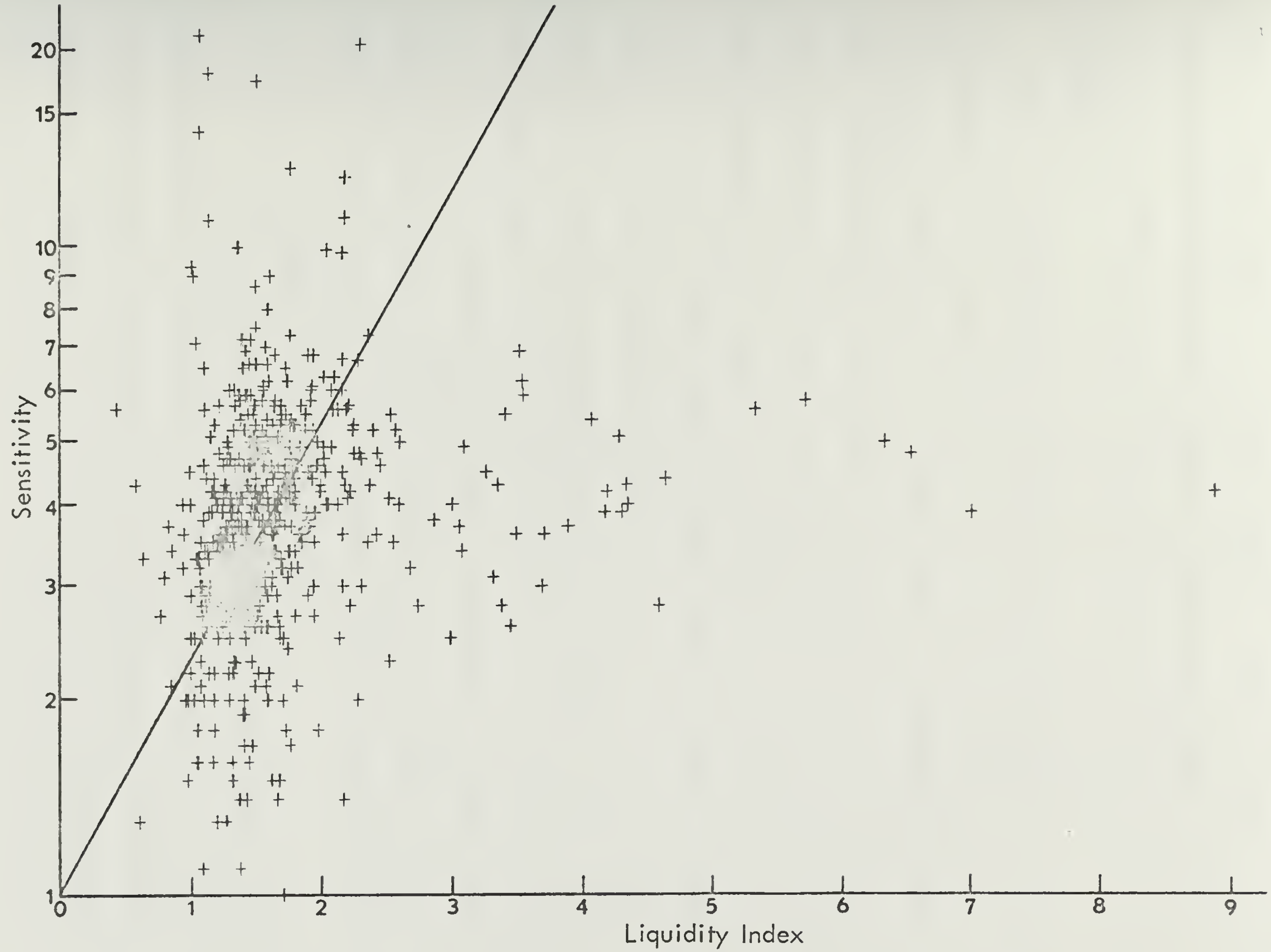

Figure 19. Liquidity Index versus Sensitivity Relationship

may be somewhat oversimplified and that the true correlation between the two elements might vary for different broad depositional regions. If these various relations can be identified when more data becomes available, it may well be possible to collect disturbed samples, measure the remolded strength, and thereby obtain values of the original shear strength by multiplying the remolded strength by the sensitivity obtained from a plot similar to Figure 19.

Shear strengths for the available data were computed in this manner and subjected to a regression on the true shear strengths, with a resulting correlation coefficient of .725 (RSQ = .525). Although this translates to about a 20% increase in explanation of the variability of shear strength over equation (5), it should be realized that the true remolded strength must be measured and therefore the procedure is not applicable for use on material which has dried below its natural water content. Strangely enough, when the results of equation (8) were substituted for the original water content in calculating liquidity index, the computed - true shear strength correlation coefficient was exactly the same as that indicated above, and the values of computed shear strength were identical to three significant figures in most cases. The 95% confidence limits using this method were nearly 10 gm/cm^2 closer to the regression line than those of Figure 16.

b. Liquid Limit - Water Content

Of considerable interest in this investigation was the high correlation (.802) existing between water content and liquid limit. The constant term in the equation for the regression line proved to be relatively unimportant, and therefore the line was forced through the origin, with virtually no decrease in the correlation coefficient (Figure 20). The equation for this relationship is:

$$WC = 1.352(LL) \tag{10}$$

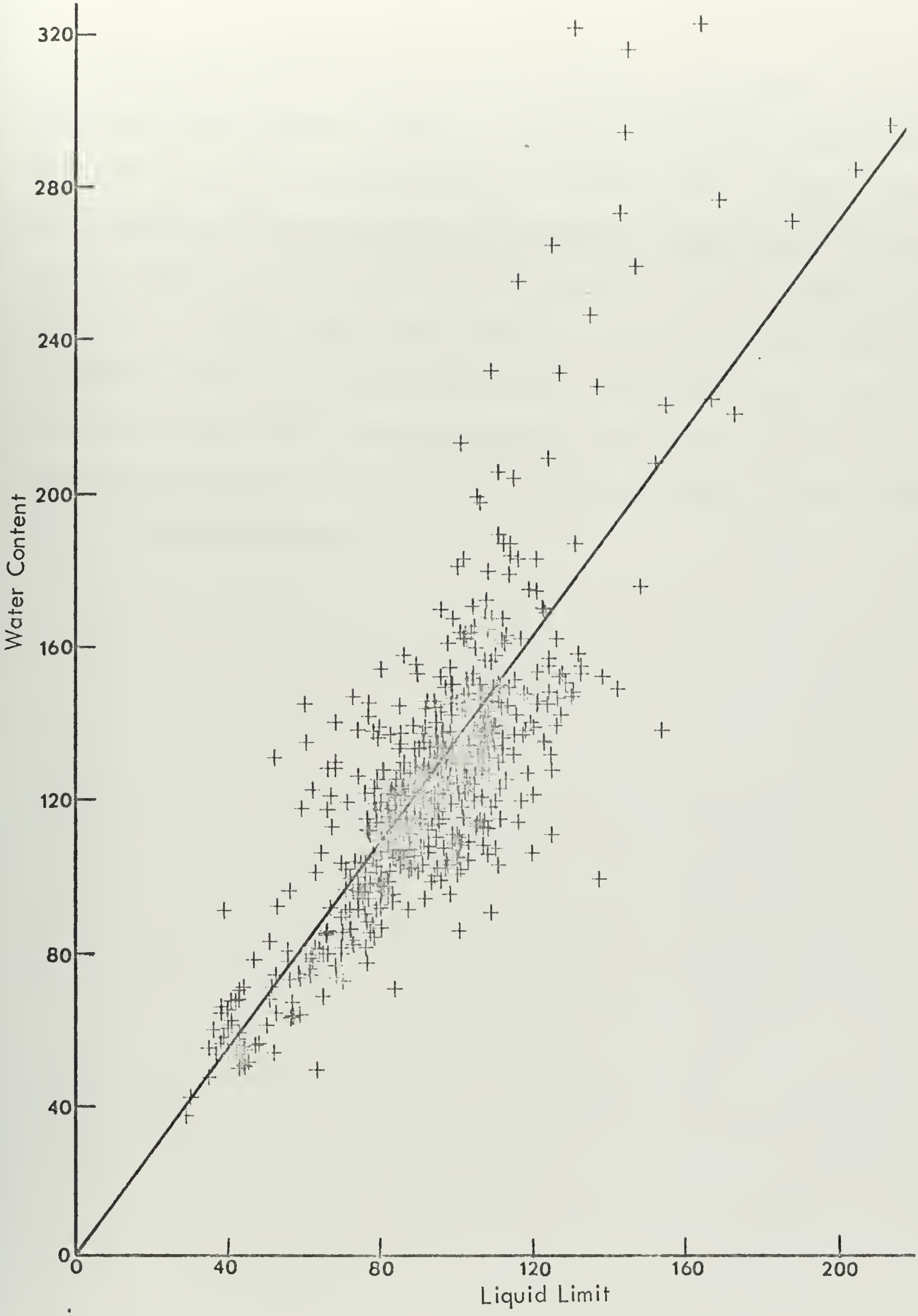

Figure 20. Water Content versus Liquid Limit Relationship

One possible explanation for this correlation is possibly that fully saturated marine sediments exist in a narrow range of water contents at some fairly constant percentage above the liquid limit. If true, this would mean that the water content is determined to some degree by the same factors which act to control liquid limit, and vice versa. This theory is supported by the fact that liquid limit and water content have similar correlation coefficients with plastic limit, median grain size, and plasticity index (Table VIII). As may be noted in the table, liquid limit was completely independent of depth in the core, whereas water content and depth are inversely related.

TABLE VIII

WATER CONTENT AND LIQUID LIMIT CORRELATION
COEFFICIENTS WITH OTHER PARAMETERS

PARAMETER	WC	LL	PL	D	$1/D^{.3}$	φ	PI	LI
Water Content	-	.802	.773	-.141	.178	.316	.501	.444
Liquid Limit	.802	-	.669	.013	.052	.416	.832	-.039

WC = Water Content

LL = Liquid Limit

D = Depth in the core

φ = Median grain size (φ units)

PI = Plasticity index

PL = Plastic limit

LI = Liquidity index

V. CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

The results of this data review and analysis indicate that several conclusions of interest can be drawn:

1. The liquid limit of marine sediments is not a reproducible quantity by present techniques.

2. Utilizing equation (5), the shear strength of deep sea sediments may be estimated to an accuracy of $\pm$ 40 gm/cm^2 at the 95% level of significance. This equation will undoubtedly be improved as additional data becomes available.

3. Original values of water content can be determined with a fairly high degree of accuracy utilizing equation (8) or (9).

4. The water content of the sediments investigated was highly dependent on the value of liquid limit.

5. The liquidity index - logarithm sensitivity relation observed by Richards (1962) and Bjerrum (1954) appears to be valid.

B. RECOMMENDATIONS

1. Extensive use of the Casagrande liquid limit device indicates that a revision of this test is necessary for application to marine sediments. Not only does the device and the type of tool used result in variable readings, but the dependence on the operator is entirely too great for useful engineering determinations. ASTM Special Technical Publication 254 (1960) contains several excellent recommendations for revision of this test.

2. As a result of their naturally saturated state and the physical changes which occur upon drying, a question arises as to the validity of ASTM procedure D-421-58 when applied to saturated samples obtained in oceanic coring. A review of all soil tests affected by procedure D-421-58 (when applied to marine sediments) is considered a necessity to determine the effects of drying.

3. Serious doubt exists regarding the reproducibility of plastic limit and median grain size of fine grain oceanic sediments once the material has dried. Therefore, it is recommended that further studies be made in this area.

4. The apparent dependence of liquid limit on organic content, indicates that further research is warranted in an effort to correlate these two parameters.

APPENDIX A

DATA ANALYZED

The majority of the data analyzed is included in this appendix. Data from 17 of the cores (accounting for 84 data points) was loaned for this study, however, it was not released for publication by the collecting agency.

The following abbreviations are used in the tabulations:

Ref. No.	Reference Number (Tables II, III, and IV)
SS	Shear Strength
gm	grams
cm	centimeters
WC	Water Content
LL	Liquid Limit
PL	Plastic Limit
MGS	Median Grain Size
PHI	Median grain size in Wentworth phi units
mm	Median grain size in millimeters
PI	Plasticity Index
LI	Liquidity Index
SENS	Sensitivity

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
1	3.8	42.9	116.6	97.6		7.32	0.0063			
	34.3	26.4	125.5	90.0		8.39	0.0030			
	64.7	34.2	116.5	85.6		8.9	0.0021			
	95.3	23.4	106.5	87.2		8.97	0.0020			
	125.7	22.3	117.4	85.9		8.49	0.0028			
	151.1	21.9	115.5	81.5		8.65	0.0025			
2	3.8	61.5	141.8	119.5		9.49	0.0014			
	34.3	25.5	143.4	95.3		12.0	0.0002			
	64.8	13.2	147.1	105.6		9.12	0.0018			
	95.3	20.3	101.2	78.4		8.83	0.0022			
3	3.8	34.9	150.1	115.6		11.9	0.0002			
	34.3	34.2	167.2	108.2		9.49	0.0014			
	64.8	21.1	150.5	103.9		11.1	0.0005			
	95.3	21.2	92.2	37.8		9.12	0.0018			

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
4	3.8	12.2	176.9	112.9		9.59	0.0013			
	34.3	27.6	141.5	104.0		9.04	0.0019			
	64.8	7.7	133.1	79.1		8.43	0.0029			
	95.3	5.8	63.4	93.9		11.12	0.0005			
	125.7	16.2	138.3	85.3		8.90	0.0021			
	156.2	12.9	123.7	81.6		9.12	0.0018			
5	8.3	18.4	177.9	116.1		9.49	0.0014			
	38.7	21.1	148.7	104.4		9.21	0.0017			
	69.2	26.9	130.9	93.3		9.39	0.0015			
	99.7	30.3	130.8	101.1		9.12	0.0018			
	130.2	31.1	122.0	65.9		7.83	0.0044			
	160.7	26.6	136.6	104.4		9.04	0.0019			
	191.1	26.0	130.3	99.4		9.59	0.0013			
6	34.3	41.5	100.1	119.7		7.46	0.0057			
	64.7	26.4	148.9	105.4		7.87	0.0043			
	95.3	21.2	153.0	106.0		8.25	0.0033			
	125.7	36.3	123.6	96.6		8.9	0.0021			

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
7	3.8	11.7	202.0	130.5		9.29	0.0016			
	34.3	19.7	159.5	114.5		9.21	0.0017			
	64.8	22.4	143.7	105.8		9.21	0.0017			
	95.3	31.6	134.8	103.5		9.21	0.0017			
	125.7	16.7	140.0	91.5		8.49	0.0028			
	156.2	13.4	138.3	93.6		12.0	0.0002			
8	3.8	18.0	164.0	124.9		12.0	0.0002			
	34.3	18.4	149.1	106.6		12.0	0.0002			
	64.8	17.9	141.7	108.5		10.7	0.0006			
	95.3	23.0	136.6	99.4		11.6	0.0003			
	125.7	24.3	211.9	96.6		10.6	0.0007			
	156.2	31.6	132.5	94.0		11.7	0.0003			
	186.7	37.6	133.3	103.4		10.9	0.0005			
	217.2	30.7	128.5	99.8		11.4	0.0004			
	247.7	29.7	129.5	95.2		9.2	0.0017			

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
9	3.8	25.7	161.3	123.7		9.59	0.0013			
	34.3	31.4	169.9	150.8		9.49	0.0014			
	64.8	33.0	144.1	110.9		9.49	0.0014			
	95.3	19.1	151.5	98.0		9.49	0.0014			
	125.7	34.9	139.3	107.4		10.5	0.0007			
	156.2	54.2	135.3	88.0		9.59	0.0013			
	186.7	23.7	162.3	78.5		9.49	0.0014			
	217.2	22.1	153.6	88.6		10.7	0.0006			
10	3.8	46.4	155.5	146.8		9.39	0.0015			
	34.3	34.0	196.6	106.8		9.21	0.0017			
	64.8	31.6	138.2	94.9		9.39	0.0015			
	95.3	27.9	127.3	93.4		9.71	0.0012			
	125.7	35.6	143.9	105.0		9.49	0.0014			
	156.2	32.3	127.4	68.4		8.16	0.0035			
	186.7	76.9	122.9	78.0		8.65	0.0025			

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
11	3.8	54.1	118.0	106.7		9.29	0.0016			
	34.3	71.0	112.7	93.9		9.21	0.0017			
	64.8	52.7	122.0	96.2		9.21	0.0017			
	95.3	52.1	140.6	100.4		9.39	0.0015			
	125.7	40.8	146.5	99.0		9.12	0.0018			
	156.2	139.7	125.2	102.1		8.59	0.0026			
12	3.8	23.2	125.5	81.8		9.39	0.0015			
	34.3	46.8	127.2	76.5		9.83	0.0011			
	64.8	75.9	115.5	78.2		9.21	0.0017			
	95.3	91.8	140.0	105.7		9.12	0.0018			
13	3.8	44.6	121.7	89.7		8.77	0.0023			
	34.3	41.8	125.5	97.8		9.04	0.0019			

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
14	3.8	51.7	111.4	106.8		9.39	0.0015			
	34.3	65.7	130.2	94.0		9.39	0.0015			
	64.7	23.5	142.1	138.8		9.39	0.0015			
	95.3	69.2	142.6	95.7		9.12	0.0018			
	125.7	59.8	122.7	92.7		9.12	0.0018			
	156.2	58.1	129.4	88.1		9.12	0.0018			
	186.7	79.9	136.3	96.6		8.97	0.0020			
	217.2	61.5	138.6	107.3		9.04	0.0019			
	308.6	94.2	61.2	84.9		7.65	0.0050			
15	34.3	21.5	129.6	97.7		9.12	0.0018			
	64.8	30.9	133.4	100.6		9.29	0.0016			
	95.3	70.3	139.2	98.5		9.39	0.0015			
	125.7	58.7	131.6	96.8		8.97	0.0020			
	156.2	83.3	118.7	90.9		9.59	0.0013			
	186.7	75.5	124.6	85.6		9.59	0.0013			
	217.2	61.2	128.6	94.0		9.04	0.0019			
	247.7	54.6	138.9	99.8		9.39	0.0015			
	278.1	58.3	142.1	113.9		9.83	0.0011			

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
16	3.8	32.3	129.7	93.9		9.49	0.0014			
	34.3	74.9	121.8	95.7		9.49	0.0014			
	64.8	77.8	130.2	100.1		9.59	0.0013			
	95.3	46.6	141.5	90.8		9.83	0.0011			
	125.7	57.2	130.4	86.9		9.39	0.0015			
	156.2	62.1	112.9	88.5		9.21	0.0017			
	186.7	75.5	125.8	92.1		9.71	0.0012			
	2 7.2	61.2	118.5	84.9		9.21	0.0017			
	247.7	58.6	129.5	94.0		9.59	0.0013			
	278.1	71.1	134.5	99.8		9.39	0.0015			
17	3.8	9.8	157.3	75.4		9.12	0.0018			
	34.3	27.6	137.5	73.6		9.71	0.0012			
	64.8	39.7	154.8	71.0		11.0	0.0005			
	95.3	42.7	113.2	75.3		9.59	0.0013			
	125.7	34.3	111.5	74.9		9.12	0.0018			
	156.2	56.9	115.1	82.3		9.71	0.0012			
	186.7	62.6	138.5	85.0		9.49	0.0014			
	217.2	108.0	135.2	90.4		9.49	0.0014			
	279.4	74.2	132.1	81.7		7.65	0.0050			

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS PHI	MGS mm	PI	LI	SENS
18	3.8	30.2	123.5	90.8		9.49	0.0014			
	34.3	56.6	135.7	93.9		9.49	0.0014			
	64.8	25.5	137.8	97.7		9.39	0.0015			
	95.3	38.0	136.4	91.7		9.83	0.0011			
	125.7	41.5	136.3	90.0		10.7	0.0006			
	156.2	60.8	118.6	88.4		9.59	0.0013			
	186.7	53.8	127.1	83.0		8.65	0.0025			
	217.2	48.4	123.4	88.1		9.49	0.0014			
	247.7	69.2	134.1	88.2		9.29	0.0016			
19	3.8	34.6	132.6	84.9	34.9	10.12	0.0009	50.0	1.95	6.1
	19.0	25.1	135.6	79.3	31.4	9.71	0.0012	47.9	2.18	4.5
	34.3	36.8	145.8	99.1	35.9	9.97	0.0010	63.2	1.74	6.5
	49.5	57.9	160.4	112.7	33.6	10.97	0.0005	79.1	1.60	6.6
20	3.8	27.6	146.9	102.9	38.5	10.12	0.0009	64.4	1.68	4.0
	19.0	63.4	127.1	107.5	30.9	9.71	0.0012	76.6	1.26	4.2
	34.3	32.2	146.7	118.5	32.9	10.49	0.0007	85.6	1.33	3.1
	49.5	40.3	149.4	110.9	31.2	10.97	0.0005	79.7	1.48	3.2
	64.8	48.5	145.0	121.3	34.0	10.12	0.0009	87.3	1.27	3.6
	80.0	100.7	134.8	123.2	34.8	10.29	0.0008	88.4	1.13	4.4

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
21	3.8	45.9	127.6	91.6	38.0	10.29	0.0008	53.6	1.67	3.4
	19.0	33.7	131.5	103.9	32.0	10.49	0.0007	71.9	1.38	4.7
	34.3	40.2	148.6	110.8	31.4	10.49	0.0007	79.4	1.48	4.9
	49.5	47.8	141.4	115.9	32.0	10.29	0.0008	83.9	1.30	3.2
	64.8	45.3	142.4	108.3	30.4	10.12	0.0009	77.9	1.44	6.9
22	3.8	53.8	124.9	102.6	38.7	10.12	0.0009	63.9	1.35	3.7
	19.0	27.6	148.5	96.9	35.6	10.29	0.0008	61.3	1.84	4.6
	34.3	26.6	142.3	95.9	32.4	10.49	0.0007	63.5	1.73	4.4
	49.5	33.7	151.0	104.1	33.0	10.97	0.0005	71.1	1.66	3.9
	64.8	51.5	127.1	95.7	31.6	10.71	0.0006	64.1	1.49	5.5
	80.0	30.2	128.9	86.2	31.5	10.29	0.0008	54.7	1.78	5.3

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
23	3.8	43.8	148.6	113.9	39.7	9.97	0.0010	74.2	1.47	7.2
	19.0	23.1	162.3	113.2	42.5	9.12	0.0018	70.7	1.69	4.2
	34.3	11.5	203.6	115.2	48.0	9.49	0.0014	67.2	2.32	20.5
	49.5	12.4	208.8	124.1	52.9	10.12	0.0009	71.2	2.19	11.1
	64.8	38.1	161.0	111.8	66.7	9.97	0.0010	45.1	2.09	6.0
	80.0	14.1	166.8	99.1	42.6	9.83	0.0011	56.5	2.20	4.3
	95.2	33.3	148.1	142.3	36.8	9.29	0.0016	105.5	1.05	3.3
	110.5	54.2	143.7	113.6	39.6	9.49	0.0014	74.0	1.41	7.2
	125.7	42.8	141.1	107.5	41.5	8.97	0.0020	66.0	1.51	5.7
	141.0	21.6	157.0	110.3	45.5	9.71	0.0012	64.8	1.72	4.2
	156.2	29.0	164.5	104.7	51.3	10.12	0.0009	53.4	2.12	6.3
	171.4	32.5	150.5	102.6	32.4	9.49	0.0014	70.2	1.68	5.1
	186.7	88.1	59.6	40.4	24.4	7.39	0.0060	16.0	2.20	12.8
24	3.8	23.5	149.4	98.5	45.2	9.71	0.0012	53.3	1.95	5.2
	19.0	30.9	136.7	91.1	32.1	9.49	0.0014	59.0	1.77	4.9
	34.3	35.4	134.2	60.5	31.7	9.39	0.0015	28.8	3.56	6.2
	64.8	78.7	112.0	82.5	33.7	9.12	0.0018	48.8	1.60	4.1

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
25	3.8	40.8	128.5	99.9	46.8	9.49	0.0014	53.1	1.54	2.8
	19.0	69.7	118.1	94.0	44.0	9.59	0.0013	50.0	1.48	4.0
	34.3	89.4	126.5	106.8	40.9	9.39	0.0015	65.9	1.30	3.7
	49.5	54.3	133.0	108.4	34.4	9.12	0.0018	74.0	1.33	3.6
	64.8	32.1	117.7	82.2	31.6	8.77	0.0023	50.6	1.70	3.8
	80.0	26.4	113.5	78.9	31.9	8.39	0.0030	47.0	1.74	4.6
	95.2	24.5	111.4	76.7	32.5	7.34	0.0062	44.2	1.78	4.3
	125.7	181.3	117.5	108.9	33.7	9.29	0.0016	75.2	1.11	4.6
	141.0	72.3	129.8	100.8	36.4	9.59	0.0013	64.4	1.45	3.7
	156.2	98.1	122.3	111.5	37.5	9.71	0.0012	74.0	1.15	3.9
	171.4	49.3	144.5	111.2	39.7	9.59	0.0013	71.5	1.47	5.0
	186.7	28.1	132.8	90.4	37.0	9.21	0.0017	53.5	1.79	5.4
	201.9	42.3	98.8	72.3	35.2	8.59	0.0026	37.1	1.71	5.7
	217.2	122.7	92.7	83.6	28.6	8.59	0.0026	55.0	1.17	3.9

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
26	3.8	36.8	123.6	97.7	41.7	9.29	0.0016	56.0	1.46	2.7
	19.0	44.6	121.0	95.4	37.4	9.21	0.0017	58.0	1.44	2.9
	34.3	50.6	130.3	108.8	40.0	8.77	0.0023	68.8	1.31	3.4
	49.5	23.3	124.5	84.2	34.1	8.29	0.0032	50.1	1.80	4.1
	64.8	17.0	122.4	78.8	32.6	7.94	0.0041	46.2	1.94	5.8
	80.0	14.1	125.6	74.1	31.7	7.21	0.0068	42.4	2.21	5.6
	95.2	20.7	112.0	67.6	29.5	9.49	0.0014	38.1	2.17	6.0
	110.5	122.7	129.1	98.5	44.4	7.97	0.0040	54.1	1.57	6.1
	125.7	81.8	130.5	105.4	40.3	9.59	0.0013	65.1	1.39	3.4
	141.0	99.8	132.6	112.4	34.5	9.71	0.0012	77.9	1.26	4.6
	156.2	46.2	138.5	104.7	36.6	9.49	0.0014	68.1	1.50	4.7
27	3.8	19.9	144.6	100.4	43.8	9.39	0.0015	56.6	1.78	7.3
	19.0	26.2	136.8	85.4	31.7	10.12	0.0009	53.7	1.96	6.8
	34.3	31.3	136.4	82.5	38.6	9.71	0.0012	43.9	2.23	5.7
	49.5	31.5	136.8	96.1	40.9	9.59	0.0013	55.2	1.74	5.5
	64.8	31.9	145.0	94.3	40.3	9.71	0.0012	54.0	1.94	6.0
	80.0	42.1	110.4	77.5	32.8	9.83	0.0011	44.7	1.74	4.4
	95.2	50.1	117.8	84.4	28.2	9.83	0.0011	26.2	1.59	5.1
	110.5	67.3	104.0	83.4	30.5	9.39	0.0015	52.9	1.39	4.1
	125.7	46.0	114.4	76.[illegible]	30.3	9.71	0.0012	46.5	1.81	4.4
	141.0	42.4	119.5	86.6	32.2	9.59	0.0013	54.4	1.60	4.8
	156.2	36.8	118.4	78.6	35.7	9.59	0.0013	42.9	1.93	3.7

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
28	3.8	8.8	168.9	95.9	37.2	9.83	0.0011	58.7	2.24	4.2
	19.0	21.2	121.2	82.6	30.5	8.21	0.0034	52.1	1.74	4.1
	34.3	26.2	135.9	94.7	32.0	8.77	0.0023	62.7	1.66	6.8
29	3.8	8.1	182.0	101.8	51.2	9.97	0.0010	49.9	2.62	5.0
	19.0	20.3	145.1	92.1	45.6	9.59	0.0013	46.5	2.14	4.0
	34.3	19.1	198.8	105.5	38.1	7.77	0.0046	67.4	2.38	7.3
	49.5	43.2	129.6	94.8	37.5	9.04	0.0019	57.3	1.61	3.3
30	3.8	50.5	137.5	118.2	43.5	9.49	0.0014	74.7	1.26	3.5
	19.0	52.4	130.6	107.0	38.7	9.59	0.0013	68.3	1.35	3.4
	34.3	94.7	115.4	90.7	30.1	9.04	0.0019	60.6	1.41	4.1
	49.5	55.9	137.1	105.5	36.2	9.49	0.0014	69.3	1.46	4.6
31	3.8	5.6	154.8	89.6	34.4	9.71	0.0012	55.2	2.18	3.0
	19.0	5.0	157.1	86.3	31.8	8.12	0.0036	54.5	2.30	2.0
	34.3	30.2	112.3	77.4	28.7	9.59	0.0013	48.7	1.72	4.4
	49.5	23.1	143.4	94.5	37.6	9.83	0.0011	56.9	1.86	3.6
	64.8	16.4	149.3	103.1	36.1	9.71	0.0012	67.0	1.69	2.6
32	3.8	19.5	128.8	89.5	37.3	9.83	0.0011	52.2	1.75	2.4
	19.0	28.2	129.0	68.1	28.6	7.16	0.0070	39.5	2.54	4.1
	34.3	22.8	102.5	69.8	30.8	7.27	0.0065	39.0	1.84	3.6

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
33	3.8	11.8	152.1	89.8	39.4	9.71	0.0012	50.4	2.24	2.8
	19.0	16.5	91.3	53.1	25.6	8.71	0.0024	27.5	2.39	4.3
	34.3	32.0	130.1	52.3	31.2	9.97	0.0010	21.1	4.66	4.4
	49.5	23.3	105.3	64.7	27.6	9.29	0.0016	37.1	2.09	4.9
	64.8	39.6	124.6	79.4	28.6	10.29	0.0008	50.8	1.89	5.2
	80.0	42.0	82.1	50.9	24.5	6.94	0.0082	26.4	2.18	6.7
	95.2	27.6	126.9	85.6	32.9	9.97	0.0010	52.7	1.78	3.7
	110.5	39.6	121.2	83.6	36.0	10.29	0.0008	47.6	1.79	4.5
	125.7	35.9	116.5	81.8	32.3	9.59	0.0013	49.5	1.70	4.1
	141.0	42.9	116.7	79.0	33.3	9.97	0.0010	45.7	1.82	4.6
	156.2	51.2	95.9	71.2	27.8	9.39	0.0015	43.4	1.57	6.0

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
34	3.8	34.4	115.2	82.8	36.6	10.12	0.0009	46.2	1.70	3.3
	19.0	31.5	127.2	91.4	38.4	10.49	0.0007	53.0	1.68	4.6
	34.3	40.8	120.7	84.4	33.6	10.12	0.0009	50.8	1.71	5.4
	49.5	38.2	122.1	85.9	35.2	10.12	0.0009	50.7	1.71	5.5
	64.8	28.4	114.4	83.9	31.1	9.39	0.0015	52.8	1.58	5.0
	80.0	36.3	121.8	88.9	34.7	10.49	0.0007	54.2	1.61	4.0
	95.2	27.4	123.6	89.5	35.2	10.29	0.0008	54.3	1.63	3.0
	110.5	46.4	116.9	80.4	33.1	10.12	0.0009	47.3	1.77	4.3
	125.7	41.5	123.0	86.0	33.3	10.29	0.0008	52.7	1.70	5.3
	141.0	53.3	120.6	83.8	35.4	10.29	0.0008	48.4	1.76	6.2
	156.2	50.4	114.4	83.0	27.4	9.29	0.0016	55.6	1.56	5.8
	171.4	50.4	113.5	82.6	27.8	9.71	0.0012	54.8	1.56	5.2
	186.7	51.2	110.6	86.1	36.7	10.12	0.0009	49.4	1.50	4.4

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
35	3.8	14.5	153.5	80.1	30.2	9.04	0.0019	49.9	2.47	4.6
	19.0	15.2	149.2	111.4	30.8	10.49	0.0007	80.6	1.47	3.9
	34.3	16.9	169.6	122.5	30.9	10.29	0.0008	91.6	1.51	5.3
	49.5	26.1	178.9	108.4	29.8	10.12	0.0009	78.6	1.90	5.5
	64.8	29.9	105.5	80.5	26.9	8.97	0.0020	53.6	1.47	5.9
	80.0	37.0	120.2	88.9	26.1	8.77	0.0023	62.8	1.50	4.2
	95.2	19.1	121.4	87.5	25.7	9.21	0.0017	61.8	1.55	3.4
	110.5	14.3	171.6	107.9	34.5	10.12	0.0009	73.4	1.87	3.5
	125.7	87.5	145.8	126.8	31.1	10.29	0.0008	95.7	1.20	4.1
	141.0	73.0	146.3	130.1	32.5	9.97	0.0010	97.6	1.17	4.2
	156.2	24.9	137.4	153.8	31.8	9.97	0.0010	122.0	0.87	3.4
	171.4	21.9	137.8	107.5	32.9	10.12	0.0009	74.6	1.41	2.9
	186.7	29.2	138.7	110.1	32.4	10.49	0.0007	77.7	1.37	3.3
	201.9	28.3	138.4	109.0	32.4	10.29	0.0008	76.6	1.38	3.7
36	3.8	13.3	143.7	85.0	36.7	9.21	0.0017	48.3	2.22	4.1
	19.0	40.1	149.6	106.3	35.1	9.83	0.0011	71.2	1.61	6.2
	34.3	35.1	135.4	112.2	35.8	10.12	0.0009	76.4	1.30	3.3
	49.5	21.9	155.7	107.3	29.2	9.49	0.0014	78.1	1.62	3.8
	64.8	48.4	103.2	73.3	25.5	8.59	0.0026	47.8	1.63	3.8

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
37	3.8	21.4	149.3	99.1	33.5	10.12	0.0009	65.6	1.77	3.4
	19.0	36.0	159.2	105.0	34.9	9.97	0.0010	70.1	1.77	4.1
	34.3	59.1	168.2	123.3	34.4	9.97	0.0010	88.9	1.51	7.5
	49.5	15.5	153.9	98.4	32.4	9.29	0.0016	66.0	1.84	3.2
	64.8	21.7	166.7	112.0	37.3	10.12	0.0009	74.7	1.73	4.5
38	3.8	17.1	162.8	102.1	23.7	9.83	0.0011	78.4	1.77	4.4
	19.0	30.2	127.6	92.6	38.0	10.12	0.0009	54.6	1.66	5.8
	34.3	28.1	144.5	76.9	33.3	10.49	0.0007	43.6	2.55	5.5
	49.5	28.5	118.6	71.4	30.1	9.12	0.0018	41.3	2.14	5.6
	64.8	18.8	137.1	96.7	27.9	10.29	0.0008	68.8	1.58	3.3
	80.0	50.9	148.6	109.8	32.7	9.97	0.0010	77.1	1.50	8.7
	95.2	35.2	149.6	111.1	33.2	10.71	0.0006	77.9	1.49	5.1
	110.5	32.1	138.1	79.8	27.2	9.29	0.0016	52.6	2.11	5.6
	125.7	25.4	151.3	95.9	35.4	10.49	0.0007	60.5	1.91	3.7
	141.0	25.8	133.8	85.4	31.9	9.83	0.0011	53.5	1.90	3.9
	156.2	45.8	130.7	105.8	34.5	9.97	0.0010	71.3	1.35	5.7
	171.4	31.8	98.6	137.4	26.8	9.21	0.0017	110.6	0.65	3.3
	186.7	64.2	139.6	94.7	26.4	10.29	0.0008	68.3	1.66	5.7
	201.9	33.8	125.7	108.6	52.7	10.12	0.0009	55.9	1.31	4.1
	217.2	45.8	133.5	109.9	36.3	10.49	0.0007	73.6	1.32	3.8

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
39	3.8	30.7	136.9	98.1	39.0	9.97	0.0010	59.1	1.66	4.0
	19.0	28.6	138.3	91.9	38.4	10.29	0.0008	53.5	1.87	5.7
	34.3	15.0	126.1	87.7	30.4	9.39	0.0015	57.3	1.67	2.9
	49.5	42.8	131.1	112.3	34.2	9.83	0.0011	78.1	1.24	2.7
	64.8	35.6	144.1	106.4	34.9	9.97	0.0010	71.5	1.53	4.8
	80.0	22.1	141.5	98.7	34.6	10.49	0.0007	64.1	1.67	3.9
	95.2	18.2	132.5	89.2	29.4	9.49	0.0014	59.8	1.72	3.2
	110.5	107.6	104.1	100.4	31.5	8.25	0.0033	68.9	1.05	7.1
	125.7	79.9	131.1	115.2	34.8	9.71	0.0012	80.4	1.20	5.3
	141.0	33.3	106.7	96.5	25.9	9.29	0.0016	70.6	1.14	2.6
	156.2	32.9	128.8	102.5	36.9	9.29	0.0016	65.6	1.40	2.9
	171.4	48.7	123.4	104.6	30.4	10.29	0.0008	74.2	1.25	4.1

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS PHI	MGS mm	PI	LI	SENS
40	3.8	46.5	116.4	95.3	35.5	10.12	0.0009	59.8	1.35	2.8
	19.0	55.3	119.1	91.5	30.4	9.97	0.0010	61.1	1.45	5.9
	34.3	56.3	118.2	88.9	32.3	10.12	0.0009	56.6	1.52	6.6
	49.5	57.2	117.0	94.[illegible]	29.6	10.12	0.0009	65.3	1.34	5.2
	64.8	58.8	110.3	87.8	29.6	10.12	0.0009	58.2	1.39	5.9
	80.0	45.9	120.2	86.7	29.2	10.29	0.0008	57.5	1.58	4.6
	95.2	52.2	126.6	92.8	28.1	9.59	0.0013	64.7	1.52	5.0
	110.5	69.2	116.3	94.2	31.6	10.29	0.0008	62.6	1.35	4.6
	125.7	45.1	114.2	90.5	27.4	10.29	0.0008	63.1	1.38	4.0
	141.0	44.0	113.6	86.5	26.4	10.12	0.0009	60.1	1.45	4.3
	156.2	50.5	119.5	91.6	32.7	10.12	0.0009	58.9	1.47	4.8
	171.4	65.4	114.7	89.2	32.9	10.12	0.0009	56.3	1.45	5.5
	186.7	48.3	110.0	99.0	31.3	10.12	0.0009	67.7	1.18	4.2
	201.9	39.9	116.1	87.0	29.6	10.12	0.0009	54.7	1.51	3.2

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
41	3.8	51.5	119.1	104.8	38.0	9.97	0.0010	66.8	1.21	3.4
	19.0	64.8	111.1	85.1	32.6	10.49	0.0007	52.5	1.50	5.1
	34.3	55.2	119.8	93.4	31.3	10.12	0.0009	62.1	1.43	5.9
	49.5	60.5	107.2	92.8	30.0	10.12	0.0009	62.8	1.23	5.7
	64.8	38.2	121.2	94.0	30.2	10.12	0.0009	63.8	1.43	5.2
	80.0	34.6	123.3	96.7	30.8	10.29	0.0008	65.9	1.40	3.7
	95.2	49.6	111.8	89.6	40.8	10.49	0.0007	48.8	1.45	3.2
	110.5	42.1	113.9	87.2	30.8	9.39	0.0015	56.4	1.47	4.2
	125.7	40.8	117.1	59.3	30.5	10.12	0.0009	58.8	1.47	4.6
	141.0	69.2	119.0	110.0	30.5	10.29	0.0008	79.5	1.11	4.6
	156.2	53.6	107.0	91.5	30.0	10.29	0.0008	61.5	1.25	3.9
	171.4	49.9	109.6	94.6	32.8	10.12	0.0009	61.8	1.24	3.6
	186.7	53.6	104.0	87.1	29.1	10.29	0.0008	58.0	1.29	4.2
	201.9	62.8	105.3	119.8	30.8	10.97	0.0005	89.0	0.84	3.7
42	3.8	23.8	162.9	101.0	53.7	8.08	0.0037	47.3	2.31	4.8
	19.0	57.2	127.8	89.1	62.4	7.94	0.0041	26.7	2.45	4.8
	34.3	68.6	112.8	86.3	45.3	7.77	0.0046	41.0	1.65	3.6
43	3.8	42.7	160.3	97.9	58.6	8.01	0.0039	39.3	2.59	5.2
	19.0	42.6	163.8	108.2	55.4	8.04	0.0038	52.8	2.05	4.0

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
44	3.8	15.6	178.3	113.8	46.8	8.08	0.0037	67.0	1.96	2.7
	19.0	23.3	173.8	120.9	52.9	8.29	0.0032	68.0	1.78	3.2
	34.3	48.2	146.8	101.9	55.0	8.12	0.0036	46.9	1.96	3.0
	49.5	44.0	147.1	117.7	53.1	8.04	0.0038	64.6	1.46	3.4
	64.8	39.6	145.6	103.1	46.2	8.04	0.0038	56.9	1.75	3.1
	80.0	75.8	113.0	90.7	37.8	7.46	0.0057	52.9	1.42	4.6
	95.2	77.3	120.9	100.6	43.4	7.71	0.0048	56.7	1.37	3.9
	110.5	93.4	129.0	111.2	55.5	7.71	0.0048	55.7	1.32	4.0
45	64.8	54.5	93.3	75.5	41.9	7.34	0.0062	33.6	1.53	2.7
	80.0	55.0	90.7	74.1	41.0	7.59	0.0052	33.1	1.50	3.3
	95.2	82.4	87.5	76.5	39.5	7.74	0.0047	37.0	1.30	3.0
46	3.8	63.1	143.4	111.8	63.7	7.62	0.0051	48.1	1.66	4.5
47	19.0	74.9	77.9	62.3	45.9	7.80	0.0045	16.4	1.95	4.4
	34.3	94.5	69.8	83.7	58.8	7.32	0.0063	24.9	0.44	5.6
	49.5	76.7	72.5	59.2	28.4	6.85	0.0087	30.8	1.43	3.6
	64.8	60.2	80.3	64.4	39.7	8.29	0.0032	24.7	1.64	3.6
	80.0	59.7	79.9	55.9	14.9	7.49	0.0056	41.0	1.58	3.4
	95.2	58.1	73.9	58.8	30.9	7.56	0.0053	27.9	1.54	3.4
	110.5	73.6	72.1	56.4	29.2	7.04	0.0076	27.2	1.58	3.7
	125.7	105.7	73.3	61.7	29.4	6.85	0.0087	32.3	1.36	4.1

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
48	19.0	89.9	106.8	110.1	50.3	7.18	0.0069	59.8	0.95	4.0
	34.3	90.2	105.0	84.5	50.7	7.36	0.0061	33.8	1.61	3.0
	49.5	94.6	82.6	72.5	41.8	6.95	0.0081	30.7	1.33	3.2
	64.8	81.8	83.3	78.5	45.9	7.04	0.0076	32.6	1.15	3.3
	80.0	88.1	79.2	69.7	37.4	7.39	0.0060	32.3	1.29	2.7
	95.2	63.4	62.6	57.2	29.1	6.97	0.0080	28.1	1.19	1.8
	110.5	98.4	63.0	59.0	33.1	6.87	0.0086	25.9	1.15	2.2
49	34.3	100.6	106.3	83.6	45.3	7.94	0.0041	38.3	1.59	3.0
	49.5	72.1	102.3	85.6	46.3	7.59	0.0052	39.3	1.42	2.8
	64.8	82.7	98.6	80.2	46.9	7.56	0.0053	33.3	1.55	4.1
	80.0	89.1	84.8	77.6	38.0	7.94	0.0041	39.6	1.18	3.5
	95.2	85.6	67.9	65.0	32.9	8.01	0.0039	32.1	1.09	2.1
	110.5	92.2	72.8	68.7	34.1	7.68	0.0049	34.6	1.12	2.9
	125.7	131.7	97.0	79.7	47.3	7.65	0.0050	32.4	1.53	4.1
	141.0	46.4	80.7	69.9	33.7	8.25	0.0033	36.2	1.30	2.2
50	95.2	72.3	60.3	50.3	23.8	6.80	0.0090	24.3	1.50	3.9
51	64.8	88.8	55.5	48.0	29.2	6.83	0.0088	18.8	1.40	2.8
	80.0	66.3	62.8	57.4	27.0	7.23	0.0067	30.4	1.18	1.6
	95.2	72.1	62.1	56.8	31.6	7.06	0.0075	25.2	1.21	2.6

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
52	3.8	55.0	114.3	85.4	43.6	7.16	0.0070	41.8	1.69	1.4
53	19.0	94.3	161.4	117.0	72.2	7.90	0.0042	44.8	1.99	4.6
54	49.5	91.7	95.5	74.3	38.0	7.94	0.0041	36.3	1.58	3.1
	64.8	94.6	94.8	83.4	39.0	8.34	0.0031	44.4	1.26	3.2
	80.0	74.4	94.9	74.8	43.4	7.56	0.0053	31.4	1.64	3.6
	95.2	100.9	95.5	80.5	37.7	7.71	0.0048	42.8	1.35	3.0
55	19.0	106.4	96.6	80.2	29.9	8.01	0.0039	50.3	1.33	3.9
	34.3	97.2	79.1	66.3	28.2	7.27	0.0065	38.1	1.34	3.3
	49.5	39.5	79.1	60.5	30.0	6.97	0.0080	30.5	1.61	2.0
	95.2	51.8	77.0	55.8	22.5	6.68	0.0098	33.3	1.64	3.1
	110.5	53.6	70.1	51.3	23.8	6.85	0.0087	27.5	1.68	2.7
	125.7	44.0	73.4	52.7	31.3	6.94	0.0082	21.4	1.97	3.9
	186.7	53.0	90.6	72.1	36.4	7.59	0.0052	35.7	1.52	3.1
	201.9	57.9	88.7	69.8	35.6	7.27	0.0065	34.2	1.55	3.5
	217.2	48.0	80.5	63.0	34.1	6.88	0.0085	28.9	1.61	2.6
	232.4	54.8	75.1	61.6	30.5	6.83	0.0088	31.1	1.43	2.5

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
56	26.7	61.4	52.9	42.2	26.4	9.04	0.0019	15.8	1.67	3.8
	57.1	61.6	54.9	47.3	26.9	8.12	0.0036	20.4	1.37	3.2
	87.6	55.7	50.6	45.6	27.8	8.97	0.0020	17.8	1.28	2.7
	118.1	49.9	49.1	43.2	26.0	9.04	0.0019	17.2	1.34	2.2
	148.6	55.2	49.5	44.5	23.8	8.97	0.0020	20.7	1.24	2.8
	179.1	52.3	53.9	44.6	26.4	8.90	0.0021	18.2	1.51	2.6
	209.5	44.8	50.5	43.9	32.2	9.04	0.0019	11.7	1.56	2.6
	240.0	45.4	51.5	43.2	25.9	8.77	0.0023	17.3	1.48	2.3
57	3.8	10.8	169.2	123.0	55.0	7.97	0.0040	68.0	1.86	4.9
	19.0	25.4	154.1	124.0	60.0	8.21	0.0034	64.0	0.78	2.7
	34.3	39.0	136.2	115.0	58.0	8.43	0.0029	57.0	1.41	3.4
	49.5	46.4	104.5	89.0	45.0	6.83	0.0088	44.0	1.12	3.4
	64.8	36.6	112.1	107.0	50.0	8.12	0.0036	57.0	1.10	2.5
	80.0	43.4	111.8	108.0	49.0	8.34	0.0031	59.0	1.07	3.3
58	3.8	8.8	182.3	121.0	58.0	7.74	0.0047	63.0	1.77	
	19.0	19.5	110.2	125.0	55.0	8.04	0.0038	70.0	1.41	2.9
	34.3	30.8	138.1	120.0	57.0	8.01	0.0039	63.0	1.26	3.5
	49.5	55.2	94.7	98.0	43.0	7.54	0.0054	55.0	1.11	3.8
	64.8	50.3	107.3	101.0	50.0	7.77	0.0046	51.0	1.12	3.4
	80.0	53.2	107.5	107.0	51.0	8.83	0.0022	56.0	1.00	2.5
	95.2	45.9	99.8	100.0	49.0	7.34	0.0062	51.0	0.99	1.5

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
59	3.8	9.6	150.6	115.6	45.0	8.71	0.0024	70.6	1.50	2.1
	34.3	23.6	134.1	107.7	43.0	8.65	0.0025	64.7	1.41	1.9
	64.8	20.4	134.8	103.1	37.5	8.65	0.0025	65.6	1.48	3.0
	95.2	16.2	125.8	104.9	40.4	8.83	0.0022	64.5	1.32	4.1
	125.7	39.9	133.4	101.3	40.6	8.90	0.0021	60.7	1.53	4.1
	156.2	32.7	129.3	107.2	42.4	9.21	0.0017	64.8	1.34	3.5
	186.7	36.8	110.6	87.6	37.0	8.34	0.0031	50.6	1.45	3.1
60	3.8	52.2	121.6	102.0	38.5	8.65	0.0025	63.5	1.31	4.0
	34.3	20.2	121.6	91.3	36.4	8.43	0.0029	54.9	1.55	3.3
	64.8	24.1	135.8	106.1	44.9	9.12	0.0018	61.2	1.49	3.2
	95.2	29.0	134.6	107.6	40.9	8.97	0.0020	66.7	1.40	2.9
	125.7	34.3	136.4	117.6	43.6	9.04	0.0019	74.0	1.25	3.2
	156.2	83.7	132.3	106.0	43.7	9.21	0.0017	62.3	1.42	6.5
	186.7	42.0	135.8	104.2	44.9	9.29	0.0016	59.3	1.53	4.0
	217.2	44.0	102.3	90.9	38.2	8.12	0.0036	52.7	1.22	3.5

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
61	3.8	18.8	128.2	91.3	37.2	8.43	0.0029	54.1	1.68	3.7
	34.3	15.2	144.3	98.7	43.1	8.97	0.0020	55.6	1.82	2.7
	64.8	20.9	138.6	109.9	41.5	8.90	0.0021	68.4	1.42	2.9
	95.2	32.7	136.5	109.4	42.1	9.04	0.0019	67.3	1.40	3.2
	125.7	28.5	114.3	96.0	36.9	8.29	0.0032	59.1	1.31	2.0
	156.2	24.1	136.0	106.6	41.0	9.49	0.0014	65.6	1.45	2.7
	186.7	35.5	130.1	103.1	38.5	8.71	0.0024	64.6	1.42	2.9
	217.2	38.0	123.4	103.6	40.9	9.21	0.0017	62.7	1.32	2.9
62	3.8	4.1	167.1	107.4	42.4	8.83	0.0022	65.0	1.92	
	34.3	47.1	127.1	106.6	41.1	8.71	0.0024	65.5	1.31	2.5
	64.8	21.9	144.9	107.3	40.2	8.77	0.0023	67.1	1.56	3.2
	95.2	23.1	128.7	101.7	39.5	8.97	0.0020	62.2	1.43	2.5
	125.7	10.3	133.5	103.2	37.8	8.39	0.0030	65.4	1.46	1.6
	156.2	30.9	121.8	96.1	37.7	8.83	0.0022	58.4	1.44	2.8
	186.7	15.0	123.7	100.3	40.3	9.04	0.0019	60.0	1.39	1.1
63	3.8	31.5	152.4	132.8	43.2	9.21	0.0017	89.6	1.22	2.5

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
64	3.8	22.6	149.9	128.8	44.6	9.39	0.0015	84.2	1.25	2.6
	34.3	48.4	144.0	123.9	42.0	9.39	0.0015	81.9	1.25	3.4
	64.8	74.2	147.3	130.8	44.4	8.97	0.0020	86.4	1.19	4.4
	95.2	64.8	157.6	131.8	45.5	9.12	0.0018	86.3	1.30	5.0
	125.7	49.9	154.0	132.6	41.4	9.21	0.0017	91.2	1.23	4.8
	156.2	81.8	126.2	118.6	44.2	8.90	0.0021	74.4	1.10	3.0
	186.7	103.8	141.4	127.4	42.9	8.65	0.0025	84.5	1.17	5.1
65	3.8	6.8	139.4	119.5	47.0	9.39	0.0015	72.5	1.27	2.9
	34.3	46.5	152.1	127.8	41.9	8.97	0.0020	85.9	1.28	3.7
	64.8	77.4	138.7	126.2	43.6	9.12	0.0018	82.6	1.15	2.9
	95.2	35.4	156.2	124.4	45.8	8.90	0.0021	78.6	1.40	5.4
	125.7	56.5	147.4	124.1	45.1	9.21	0.0017	79.0	1.29	4.7
	156.2	81.8	130.9	124.6	42.9	8.90	0.0021	81.7	1.08	21.1
	186.7	68.0	151.6	127.0	40.4	9.04	0.0019	86.6	1.28	4.3
66	3.8	7.5	161.4	102.8	48.3	8.08	0.0037	54.5	2.07	4.0
	34.3	14.4	128.6	97.1	44.4	8.59	0.0026	52.7	1.60	2.9
	64.8	34.1	96.5	81.2	45.7	7.56	0.0053	35.6	1.43	3.3
	95.2	41.1	84.8	65.8	32.7	6.74	0.0094	33.1	1.57	3.8

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS PHI	MGS mm	PI	LI	SENS
**										
85	146.0	91.4	89.7	109.0	28.0	7.97	0.0040	81.0	0.76	
86	5.1	37.3	53.0	52.0	22.0	7.80	0.0045	30.0	1.03	
	43.2	28.1	54.5	44.0	21.0	7.71	0.0048	23.0	1.46	2.7
	73.7	30.9	54.9	42.0	21.0	7.71	0.0048	21.0	1.62	2.2
	104.1	30.2	53.4	40.0	20.0	7.65	0.0050	20.0	1.67	
87	17.8	52.7	95.4	73.0	30.0	9.12	0.0018	43.0	1.52	
	94.0	42.9	58.2	43.0	22.0	8.39	0.0030	21.0	1.72	
	129.5	53.4	56.5	43.0	22.0	8.49	0.0028	21.0	1.64	
	149.9	65.4	49.7	44.0	22.0	8.29	0.0032	22.0	1.26	
88	5.1	33.7	95.6	75.0	27.0	8.54	0.0027	48.0	1.43	
	83.8	48.5	66.0	57.0	26.0	8.83	0.0022	31.0	1.29	

** The data from cores 67 - 84 has not been released for publication

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
89	17.1	38.0	46.8	35.0	20.0	7.08	0.0074	15.0	1.79	
	28.6	54.8	41.5	30.0	18.0	7.14	0.0071	12.0	1.95	
	43.8	47.1	36.7	29.0	18.0	6.68	0.0098	11.0	1.70	
	66.7	42.9	52.5	37.0	20.0	7.01	0.0078	17.0	1.91	
	93.3	33.7	66.8	41.0	21.0	7.87	0.0043	20.0	2.29	
	104.8	32.3	67.2	43.0	22.0	8.29	0.0032	21.0	2.15	
	120.0	27.4	69.5	43.0	22.0	8.12	0.0036	21.0	2.24	
	131.4	32.3	70.4	44.0	23.0	8.34	0.0031	21.0	2.26	
	142.9	39.4	61.5	41.0	22.0	7.97	0.0040	19.0	2.08	
	163.2	37.3	64.9	38.0	21.0	7.36	0.0061	17.0	2.58	
	174.6	33.7	64.2	40.0	20.0	7.36	0.0061	20.0	2.21	
	186.1	36.6	59.1	36.0	20.0	7.25	0.0066	16.0	2.44	
	239.4	45.0	55.6	38.0	20.0	7.16	0.0070	18.0	1.98	
90	43.2	45.7	94.2	74.0	34.0	8.65	0.0025	40.0	1.51	
	104.1	61.2	94.2	82.0	31.0	8.77	0.0023	51.0	1.24	
	132.1	46.4	106.1	82.0	30.0	9.59	0.0013	52.0	1.46	
	152.4	40.8	108.5	80.0	31.0	9.49	0.0014	49.0	1.58	

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
91	5.1	28.8	111.2	83.0	34.0	8.83	0.0022	49.0	1.58	
	15.2	49.9	102.6	76.0	33.0	8.65	0.0025	43.0	1.62	
	43.2	61.9	85.4	72.0	31.0	8.54	0.0027	41.0	1.33	
	63.5	73.1	75.9	68.0	30.0	8.39	0.0030	38.0	1.21	
	86.4	61.9	85.6	72.0	29.0	9.12	0.0018	43.0	1.32	
	116.8	64.0	97.0	76.0	31.0	9.49	0.0014	45.0	1.47	
	137.2	43.6	102.6	75.0	33.0	9.39	0.0015	42.0	1.66	
92	17.8	32.3	108.9	83.0	32.0	8.54	0.0027	51.0	1.51	
	45.7	46.4	95.1	76.0	30.0	8.43	0.0029	46.0	1.42	2.6
	73.7	66.8	80.6	76.0	30.0	8.25	0.0033	46.0	1.11	
	99.1	60.5	91.9	80.0	29.0	9.29	0.0016	51.0	1.23	
	127.0	59.8	101.3	88.0	32.0	9.59	0.0013	56.0	1.24	
93	24.4	45.0	103.9	84.0	33.0	8.77	0.0023	51.0	1.38	4.0
	73.7	43.6	90.6	74.0	29.0	9.12	0.0018	45.0	1.37	
	128.3	47.1	106.3	84.0	33.0	9.49	0.0014	51.0	1.44	

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS PHI	MGS mm	PI	LI	SENS
94	15.7	40.1	105.7	80.0	32.0	8.77	0.0023	48.0	1.53	3.4
	47.5	105.4	81.5	73.0	30.0	8.49	0.0028	43.0	1.20	
	68.6	114.6	71.7	70.0	30.0	8.59	0.0026	40.0	1.04	
	88.9	84.4	81.6	73.0	30.0	9.12	0.0018	43.0	1.20	
	99.1	62.6	86.5	78.0	30.0	9.39	0.0015	48.0	1.18	
	114.3	78.7	91.0	[illegible]	30.0	9.39	0.0015	50.0	1.22	
	134.6	75.2	90.7	79.0	31.0	9.59	0.0013	48.0	1.24	
	154.9	49.9	100.0	80.0	30.0	9.59	0.0013	50.0	1.49	4.7
95	21.2	56.2	97.8	82.0	32.0	8.97	0.0020	50.0	1.74	
	48.5	52.7	84.9	66.0	29.0	8.39	0.0030	37.0	1.51	
	65.7	85.1	78.9	65.0	28.0	8.83	0.0022	37.0	1.47	
	77.3	57.6	89.3	76.0	31.0	9.21	0.0017	45.0	1.30	
	98.0	67.5	93.5	77.0	31.0	9.49	0.0014	46.0	1.36	
	120.9	52.7	103.4	78.0	46.0	9.59	0.0013	32.0	1.81	
	138.0	60.5	99.2	74.0	32.0	9.39	0.0015	42.0	1.67	
96	17.8	30.9	108.8	82.0	30.0	8.65	0.0025	52.0	1.52	
	134.6	49.9	101.8	79.0	29.0	9.49	0.0014	50.0	1.46	
	154.9	54.1	100.2	76.0	32.0	9.83	0.0011	44.0	1.55	
97	16.3	67.1	112.8	106.0		8.39	0.0030			

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
98	18.0	57.0	249.7	163.0		8.39	0.0030			
	58.4	43.6	262.8	187.0		8.97	0.0021			
99	69.6	68.9	276.8	169.0	86.2	9.97	0.0010	82.8	2.30	6.7
100	69.6	79.5	200.7	123.0		7.39	0.0060			
101	148.6	13.0	144.9	109.0	41.1	10.71	0.0006	67.9	0.97	2.0
	429.3	65.0	114.1	111.5	45.0	10.97	0.0005	66.5	1.04	2.0
	528.3	59.0	85.2	100.8	36.1	10.49	0.0007	64.7	0.99	2.0
102	52.6	16.0	116.3	84.0	25.8	10.29	0.0008	58.2	1.36	2.3
	48.5	20.0	137.1	107.4	40.9	10.71	0.0006	66.5	1.23	3.5
103	10.0	6.6	161.4	126.0	48.0	8.97	0.0020	78.0	1.45	
	20.0	6.6	151.6	138.0	47.8	9.59	0.0013	90.3	1.15	
	39.9	28.6	134.1	123.2	44.8	9.39	0.0015	78.4	1.14	3.4
	50.0	7.5	127.2	125.2	53.5	9.49	0.0014	71.7	1.03	9.0

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
104	25.0	38.8	107.8	99.3	21.0	9.49	0.0014	78.3	1.11	1.1
	54.9	15.8	143.1	91.8	42.2	9.49	0.0014	49.6	2.04	6.3
	70.1	20.0	161.4	101.9	41.9	9.71	0.0012	60.0	1.99	1.8
	85.1	14.9	139.4	107.1	44.9	9.59	0.0013	62.2	1.52	18.0
	135.1	27.0	127.0	101.9	54.3	9.49	0.0014	46.7	1.53	2.2
	144.8	24.1	119.8	106.8	40.0	9.59	0.0013	66.8	1.19	4.2
105	30.0	10.3	132.8	90.3	38.8	8.77	0.0023	51.5	1.83	2.1
	59.9	19.9	105.5	92.7	37.0	9.12	0.0018	55.7	1.23	3.4
	70.1	43.8	84.7	70.3	33.7	8.77	0.0023	36.6	1.39	1.4
	104.6	18.5	121.1	90.4	36.6	8.34	0.0031	53.8	1.57	3.7
	139.7	30.3	114.3	95.6	39.0	9.29	0.0016	56.6	1.33	1.6
	157.5	85.4	112.7	93.4	36.1	9.21	0.0017	57.3	1.34	2.3
	178.3	32.0	131.2	96.2	41.7	9.71	0.0012	54.5	1.64	1.5
	192.3	25.2	125.5	98.3	36.8	9.71	0.0012	61.5	1.44	1.4
	215.1	42.1	121.1	91.1	38.3	9.83	0.0011	52.8	1.57	4.2
	232.9	48.8	113.3	84.3	35.2	9.59	0.0013	49.1	1.59	2.1
	243.1	55.5	111.6	92.8	36.5	9.59	0.0013	56.3	1.33	3.3
	254.8	58.3	106.9	90.7	38.9	9.59	0.0013	51.8	1.31	6.0
	269.5	69.9	106.3	88.2	36.2	9.59	0.0013	52.0	1.35	6.0
	289.6	75.7	97.8	93.4	36.3	9.59	0.0013	57.1	1.08	3.2

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
106	20.0	32.1	114.1	90.1	34.4	9.39	0.0015	55.7	1.43	1.9
	45.0	52.2	100.7	89.7	36.4	9.49	0.0014	53.3	1.21	1.3
	54.9	58.3	84.2	65.9	28.3	8.54	0.0027	37.6	1.49	1.7
	65.0	52.2	63.5	52.6	20.8	7.97	0.0040	31.8	0.81	3.1
	74.9	69.9	103.3	86.4	30.6	9.29	0.0016	55.8	1.30	3.6
	87.1	60.6	108.2	101.3	28.6	9.59	0.0013	72.7	1.09	2.3
	106.9	65.6	101.0	101.0	36.4	9.29	0.0016	64.6	1.00	2.2
	121.9	9.3	99.6	94.2	35.4	9.49	0.0014	58.8	1.09	3.0
	142.2	52.2	103.5	97.5	33.1	9.59	0.0013	64.4	1.09	3.5
107	25.0	47.1	134.0	94.9	39.1	9.71	0.0012	55.8	1.70	2.5
	54.9	20.9	133.4	95.2	36.8	9.71	0.0012	58.4	1.65	3.4
	85.1	75.7	112.9	105.3	40.1	8.97	0.0020	65.2	1.12	5.6
	104.9	20.9	98.0	95.7	38.4	9.39	0.0015	57.3	1.82	4.0
	144.8	37.0	133.1	93.1	39.1	9.59	0.0013	54.0	1.74	1.8
	175.3	30.5	134.2	91.6	37.2	9.49	0.0014	54.4	1.78	13.2
	195.1	53.9	124.9	91.6	38.8	9.59	0.0013	52.8	1.63	4.6

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
108	25.0	43.8	103.4	103.2	34.8	8.90	0.0021	68.4	1.00	2.9
	35.1	42.7	113.3	116.0	42.8	9.39	0.0015	73.2	0.96	3.6
	50.0	60.6	120.5	120.4	39.7	9.59	0.0013	80.7	1.00	4.5
	65.0	17.4	147.0	106.6	38.6	9.49	0.0014	68.0	1.59	7.0
	74.9	21.8	140.5	106.0	37.2	9.12	0.0018	68.8	1.50	3.1
	95.0	50.6	133.2	96.7	35.5	9.29	0.0016	61.2	1.60	2.6
	104.9	40.0	133.5	103.3	38.2	9.49	0.0014	65.1	1.46	6.6
	114.8	32.0	120.5	96.8	37.5	8.97	0.0020	59.3	1.40	3.8
	149.9	24.4	101.1	87.5	29.9	9.39	0.0015	57.6	1.24	3.5
	160.0	42.1	97.4	77.3	36.8	9.12	0.0018	40.5	1.50	4.2
	184.9	40.4	104.2	85.6	41.1	9.39	0.0015	44.5	1.42	2.0
	195.1	32.2	97.9	82.2	32.8	9.29	0.0016	49.4	1.32	3.1
109	13.5	16.8	106.2	87.9	39.9	10.29	0.0008	48.0	1.38	10.0
	46.0	31.1	83.9	65.9	42.8	9.59	0.0013	65.9	0.62	1.3
	55.4	25.2	119.1	85.5	39.5	10.29	0.0008	46.0	1.73	1.0

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
110	25.0	44.6	118.3	98.7	35.0	9.83	0.0011	63.7	1.31	2.7
	45.0	50.5	110.4	100.4	47.2	9.39	0.0015	53.2	1.19	2.2
	74.9	59.7	124.7	113.2	38.2	9.71	0.0012	75.0	1.15	11.0
	119.9	43.4	120.3	106.7	36.2	9.83	0.0011	70.5	1.19	2.0
	144.8	86.8	112.2	105.1	42.2	9.71	0.0012	62.9	1.11	2.0
	195.1	143.7	109.6	100.5	39.1	9.83	0.0011	61.4	1.15	18.5
	214.9	62.1	104.9	108.3	34.7	9.21	0.0017	73.6	0.95	3.2
111	15.0	15.5	117.3	101.3	45.5	9.97	0.0010	55.8	1.29	1.3
	35.1	20.2	142.5	101.3	33.7	10.29	0.0008	67.6	1.61	4.0
	85.1	101.0	144.3	121.0	51.4	10.12	0.0009	69.6	1.33	
	104.9	25.2	138.6	88.5	38.0	10.29	0.0008	50.5	1.99	5.0
	135.1	38.8	139.6	94.8	32.5	10.12	0.0009	62.3	1.72	2.0
	165.1	38.7	129.9	97.6	43.8	9.97	0.0010	53.8	1.60	3.3
	196.1	50.5	124.1	90.5	43.5	9.71	0.0012	47.0	1.71	3.2
112	35.1	58.3	102.1	111.0	47.8	9.97	0.0010	63.2	0.86	2.1
	65.0	54.2	108.2	103.2	43.5	10.12	0.0009	59.7	1.08	3.3
	85.1	50.5	113.7	106.0	41.9	9.97	0.0010	64.1	1.12	6.5
	130.0	23.3	113.1	95.5	44.1	9.97	0.0010	51.4	1.34	1.5
	175.3	48.8	108.0	98.9	41.9	9.97	0.0010	57.0	1.16	3.0
	205.2	43.4	101.3	88.4	29.9	9.97	0.0010	58.4	1.22	4.0
	245.1	54.2	93.4	91.7	45.6	9.97	0.0010	46.1	1.04	2.5

Ref. No.	Depth (cm)	SS (gm/cm^2)	WC (%)	LL (%)	PL (%)	MGS		PI	LI	SENS
						PHI	mm			
113	30.0	28.6	113.7	107.3	42.5	9.97	0.0010	64.8	1.10	2.8
	48.0	13.8	143.1	102.1	45.6	9.97	0.0010	56.5	1.73	2.5
	57.9	11.8	163.1	103.7	53.6	9.97	0.0010	50.1	2.19	1.4
	69.6	35.3	60.1	41.1	28.6	7.62	0.0051	12.5	2.52	
	80.0	7.8	132.6	97.1	40.3	9.83	0.0011	56.8	1.62	9.0
	137.2	31.1	122.0	103.1	45.2	10.12	0.0009	57.9	1.33	4.0
	152.4	35.0	96.2	74.4	29.6	9.21	0.0017	44.8	1.49	3.0
	167.1	27.1	100.7	82.7	40.1	9.39	0.0015	42.6	1.42	1.7
	178.1	54.4	85.8	80.1	35.2	9.29	0.0016	44.9	1.13	2.8
	186.4	70.5	48.5	63.5	27.7	7.39	0.0060	35.8	0.58	4.3
	196.3	48.8	77.7	61.9	29.6	9.39	0.0015	32.3	1.49	3.0
	210.8	86.8	76.7	76.8	29.9	9.59	0.0013	46.9	1.00	4.[illegible]
114	15.0	33.7	90.6	87.6	45.7	8.97	0.0020	41.9	1.07	1.8
	35.1	25.2	102.4	97.7	34.7	9.21	0.0017	63.0	1.08	15.0
	54.9	50.5	104.1	100.8	44.4	9.71	0.0012	56.4	1.06	1.6
	110.0	21.9	101.6	96.9	31.6	9.97	0.0010	65.3	1.07	1.6
	130.0	54.4	114.5	101.9	47.2	9.97	0.0010	54.7	1.23	3.5
	139.7	46.6	130.3	94.2	42.7	7.23	0.0067	51.5	1.70	1.5
	154.9	47.1	119.2	117.2	35.4	9.97	0.0010	81.8	1.02	9.3
	170.2	54.4	96.3	81.2	36.1	9.49	0.0014	45.8	1.32	4.7
	183.9	48.8	105.9	85.0	32.7	9.59	0.0013	52.3	1.40	5.8
	198.1	62.1	101.4	95.1	32.9	9.83	0.0011	62.1	1.10	2.7

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DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author)	2a. REPORT SECURITY CLASSIFICATION
Naval Postgraduate School Monterey, California 93940	Unclassified
	2b. GROUP

3. REPORT TITLE

Estimation of the Original Shear Strength of Deep Sea Sediments from Engineering Index Properties

4. DESCRIPTIVE NOTES (Type of report and, inclusive dates)

Master's Thesis; September 1970

5. AUTHOR(S) (First name, middle initial, last name)

Robert Wyman Hoag II

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
September 1970	103	54

8a. CONTRACT OR GRANT NO.	9a. ORIGINATOR'S REPORT NUMBER(S)
b. PROJECT NO	
c.	9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)
d.	

10. DISTRIBUTION STATEMENT

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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY
	Naval Postgraduate School Monterey, California 93940

13. ABSTRACT

Multiple linear regression techniques were employed in a statistical analysis of data from 114 deep sea cores in order to derive an equation for predicting shear strength from sediment engineering index properties. Water content, depth of burial, liquid limit, and plastic limit proved to be the only factors significantly influencing the strength in these cores. The multiple and individual correlation coefficients between these four parameters and the logarithm of shear relation. Additionally, other regression analysis were conducted to determine a water content prediction equation and to investigate correlations among other sediment properties. Water content is shown to be highly correlated with liquid limit. Ancillary to the above analysis, tests where conducted to determine the degree of reproducibility of original liquid limit values from dried sediment material.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Atterberg limits						
Cores						
Data						
Deep sea cores						
Deep sea sediments						
Engineering properties of marine sediments						
Liquid limit						
Marine sediments						
Regression analysis						
Reproducibility of sediment properties						
Sediment engineering properties						
Sediment cores						
Sediments						
Shear strength						
Shear strength prediction						
Statistical analysis						
Water content						
Water content prediction						

Thesis
H585 Hoag 121900

Estimation of the original shear strength of deep sea sediments from engineering index properties.